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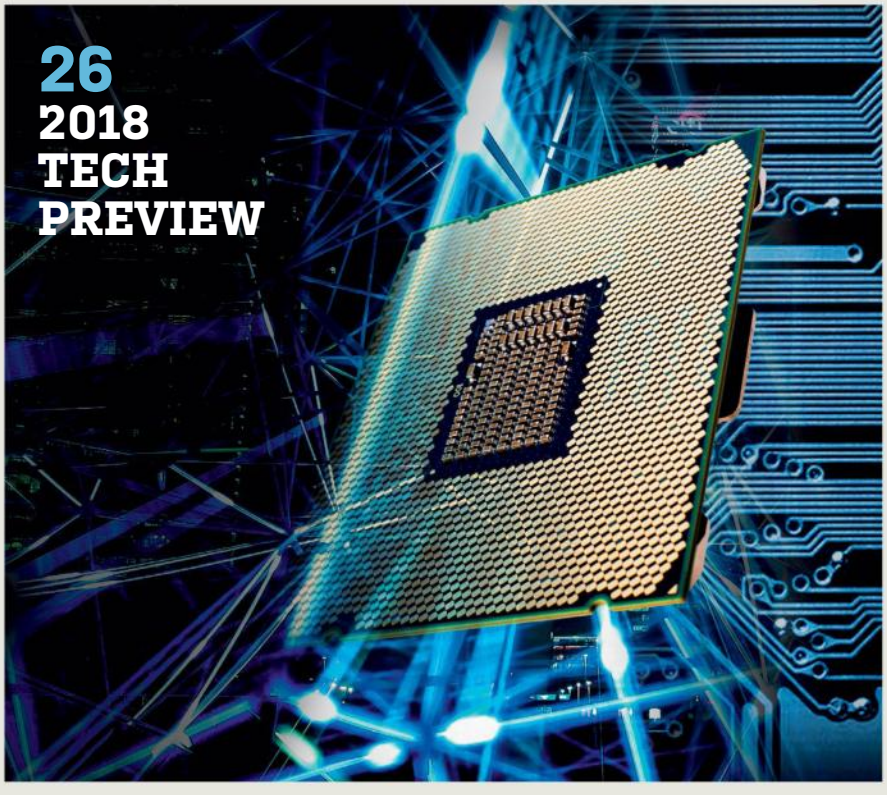

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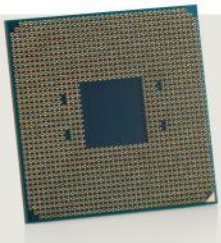

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Tuan Nguyen

LEAPING FORWARD

AS A YEAR ENDS, people get sentimental. Review the past, see what went right and what went wrong. I say, to hell with looking back. It's all about the future.

While 2017 brought us some great hardware, 2018 is going to be even better. I feel this is the year when all the exciting innovation will happen. Case in point: AMD's Radeon chief jumped ship and went to Intel. Days after, Intel announced that it plans to work on discrete GPUs! Are we going to see three main players in the graphics market? I hope so.

2018 will also be the year when VR gets really serious. Headsets are going wireless with full inside-out tracking that lets you move around in as much space as you can afford. This will force wireless video standards to improve. I hope that once this happens, content will improve.

Other fantastical things I'm looking forward to? Better screens. This means we'll see screens with higher resolutions and higher refresh rates. And higher refresh rates aren't just for gaming. They make a huge impact on the desktop, too. If you've never moved a window at 120Hz, you're missing out! In fact, the screen is our number one driver of the PC. And to drive the increased pixel density, GPUs will need to really up the ante.

And wouldn't you know—it's all very convenient that we're going to have three major players making GPUs now. Good times ahead!

Tuan Nguyen is Maximum PC*'s editor-in-chief, also known as "the pointy end of the stick." He's been writing, marketing, and raising hell in the tech industry for 19 years.*

↘ submit your questions to: comments@maximumpc.com

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THE NEWS

Intel and AMD Inside

Rivals to collaborate on hybrid mobile chips

AMD AND INTEL do not make a habit of cooperating. That's putting it mildly; they enjoy a somewhat heated rivalry. It hasn't stopped them cutting a deal, though—Intel is going to put a Radeon GPU into its mobile chips. Shock. Intel says the deal will bring together the "Intel Core H series processor, second-generation High Bandwidth Memory (HBM2), and a custom-to-Intel third-party discrete graphics chip from AMD's Radeon Technologies Group." Intel has also managed to get hold of AMD's top GPU architect, Raja Koduri, to be a senior VP, and lead its high-end graphics development team—quite an acquisition.

It is the first time since 1980 that the pair has collaborated over anything except writing industry standards. It has also been some time brewing. A year or so ago, rumors started that the two were in cahoots over GPUs, and both sides went to the trouble of denying it. Issuing strident denials is, of course, pretty suspicious, so this announcement hasn't exactly come as a huge surprise.

The new hybrid design will be the first mobile model to use Intel's Embedded Multi-die Interconnect Bridge (EMIB) technology. This does pretty much what the name says—it links together components on a single die with high-speed die-to-die interconnects. Coupled with the HBM2, it'll give the GPU real room to breathe.

Intel's own efforts at onboard graphics have never really sparkled. This deal gives it the missing piece it needs to power mobile, NUC, and other skinny hardware that has the oomph to play games without the need for extra silicon.

On the surface, it may look as if Intel is getting the better deal here, getting much-needed GPU technology, and giving its own APUs an edge over the Ryzen Mobile. However, Intel already has 70 percent of the integrated GPU market, and current Ryzen Mobile chips aren't aimed at the gaming market. No, AMD and Intel both have another rival: Nvidia, a company that has 70 percent of the discrete GPU market. This deal does Nvidia no favors; sales that the hybrid steals from the discrete GPU market are more likely to be Nvidia's loss than AMD's, which will get a cut into the bargain.

Intel has always lacked high-end GPUs, specifically ones that can compete in the lucrative server and AI markets. Here it's Nvidia, rather than AMD, that is standing in the company's way. How long this hybrid design will last is questionable. Intel has just hired one of the world's best GPU architects, and created a new department for him to run: the Core and Visual Computing Group. Something is brewing here of much more importance in the long run—another attempt at an high-end GPU architecture is the supposition. Intel has tried this before. The last attempt was Larrabee, which was canceled in 2009, just as the first silicon appeared. It suffered from being based around x86 cores, which just weren't suited to the job. This time around, the company has a man who knows how to build a modern GPU from the ground up.

AMD and Intel have not suddenly become good friends either; only this summer, Intel was trash-talking AMD as having a poor track record, and being an inconsistent supplier (despite making plans for it to become one of its own behind the scenes). This move is an expedient one by both parties.

The first fruits of the union are expected in the first quarter of 2018, codename Hades Canyon. They feature a quad-core Kaby Lake H, and have tentatively been put at running at 68W and 96W. "Leaked" benchmarks show performance levels between a Radeon RX 560 and 570. Expect thin, light laptops with some impressive gaming abilities to follow. **–CL**

Intel's Kaby Lake H sharing silicon with an AMD GPU is as unlikely a pairing as in any sitcom, given how the two snipe at each other.

> A year or so ago, rumors started that the two were in cahoots over GPUs.

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BATTLEFRONT II'S ONLINE BATTLE

Developers misjudge gamers' reactions

STAR WARS BATTLEFRONT II has caused a disturbance in the force, and not in the way that Electronic Arts wanted. It's all down to how hero characters are unlocked. The likes of Luke Skywalker and Darth Vader originally required crystals, which you earned in play, or bought. It took about 40 hours of play to unlock a single hero character. If you wanted to max-out on everything, it would take thousands of hours of play, unless you reached for real money. A system of Loot Crates also attracted criticism for being, essentially, akin to gambling. These can also be purchased, but the contents are random, making the process basically a slot machine.

Those unwilling to spend the extra felt unfairly disadvantaged by richer or less principled players who simply buy a bucketload of Loot Crates and start crafting high-power upgrades from the start. There followed an online storm. EA reacted poorly at first, delivering an unconvincing rationale that merely added fuel to the online fire. This was followed by a reduction in the number of points required. Finally, it dropped the in-game payment system altogether. In a statement it said that it was "sorry we didn't get this right." All upgrades and characters now have to be earned through gameplay. However, EA also said that the ability to purchase upgrades in-game may become available at a later date.

Big games cost seriously big money to make, and in-game micropayments can be lucrative. However, they've previously been a feature of mobile games that are very cheap, or free to play. If you have to pay to win, having already paid, expect trouble.

We may well have Disney to thank for EA's climb-down; rumor has it that its executives were frustrated at the level of unhappiness toward one of its prime assets. It's still not fully fixed either. The Loot Crate system adds a randomness that doesn't necessarily reward dedicated play. You can still grind out hours for little if you get the wrong drop. **–CL**

APPLE AR BY 2019

FULLY STANDALONE HEADSET PLANNED

APPLE IS WORKING ON an aggressive roadmap for augmented reality headsets, which it is hoped will be ready for 2019. It launched the developer's kit, ARKit, in 2017. Unlike existing platforms, this won't be tethered, or running from a smartphone, but rather a fully integrated standalone headset, complete with its own OS, and all the requisite hardware. CEO Tim Cook believes that "AR is going to change the way we use technology forever."

Apple has just spent $30 million on buying Vrvana, which produced the acclaimed Totem headset. This was never officially released, and instead of the overlay system of HoloLens, it uses cameras to capture the immediate environment, then mixes the results for display. There's no transparent overlay effect; you get a full mix of real and virtual in one, as on a smartphone. This could be a clue to how the new kit will work. Apple might be a little late to the party, but it does has an enviable record of making cool stuff people want. **–CL**

GAMING DRAINS SURFACE 2

Not enough juice to run full-on gaming

MICROSOFT'S SURFACE 2 is a nice bit of gear, and its ability to run games is impressive. As it should be—the 15-inch model comes with an Nvidia 1060 and costs $2,500. This ability comes at a price, though: The battery drains even when plugged in. Yep, turn the Power Mode slider up to max, and start playing a demanding game, and the battery starts to drain by 10 percent or more every hour. It transpires that the power supply (labeled as 102W) can't cope with full-on games, which push the GPU into using 80W or more, leaving little power for much else. It won't run flat; it throttles back enough to keep you alive.

Embarrassing for a machine marketed as high-power gear, Microsoft says it was designed to deliver "unmatched power and performance." Only clearly it wasn't thoroughly tested at the limits running games, despite the promotional material including images of hipsters gaming. **–CL**

Tech Triumphs and Tragedies

A monthly snapshot of what's good and bad in tech

TRIUMPHS

SAMSUNG Z-SSD SURFACES
New NAND memory technology offers 3.2GB/s sequential data rates—more than fast enough to challenge Intel Optane.

NINTENDO DOMINATES
Forget Xbox and PS4—Nintendo has 66 percent of the console market, with Switch at number one, and SNES Classic at two.

4K VIA THE ANTENNA
The FCC has approved broadcast 4K TV, although you'll need a new box. First tests due in spring.

TRAGEDIES

UBER PAYS RANSOM
After hackers stole 50 million user details last year, it transpires Uber paid $100K to make the problem go away.

FAKE CRYPTOCURRENCY
After raising $375K for an initial coin offering, Confido and its supposed CEO have vanished. A classic exit scam.

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TECH TALK

Intel Makes Major Moves in Graphics and Learning

THERE HAS BEEN A SERIOUS SHAKEUP in the world of graphics technology this past month, with three major announcements. First, Intel announced a partnership with AMD, where it will integrate a custom Radeon graphics solution on a future Intel Core CPU. It will use Intel's Embedded Multi-Die Interconnect Bridge (EMIB) for communicating with a mobile AMD graphics solution. The goal is thinner and more powerful gaming laptops.

And this isn't a low-end graphics solution. Current indications are that the top configuration will have 1,536 AMD GCN cores, clocked at 1,000–1,150MHz. That's somewhat slower than an RX 570, but for a laptop, it's a huge step up from Intel's previous HD Graphics and Iris solutions. More interesting is that the solution will also utilize HBM2 memory, potentially 2–4GB, which will provide significant VRAM bandwidth advantages compared to previous integrated solutions. The only real question remaining is what sort of power requirements the chips will have, and how much the laptops will cost.

That's a huge announcement, but it's only the beginning. Days later, it was revealed that AMD's Raja Koduri, former head of the Radeon Technology Group, was leaving the company. He will now be the chief architect and senior VP of Intel's new Core and Visual Computing Group. Raja says he's "incredibly excited to join the Intel team and have the opportunity to drive a unified architecture vision across its world-leading IP portfolio that helps accelerate the data revolution." That sounds as though Intel wants to use his talent to do more than just faster graphics, which brings us to the third piece of news.

Intel already has products that compete in the machine learning and supercomputing arena, specifically its Xeon Phi processors. These are found in many of the world's fastest supercomputers, including China's Tianhe-2, which currently occupies the number two position on the Top 500. During the past year, Intel also acquired Nervana Systems, a company working on a custom ASIC for machine learning applications. Intel's upcoming Nervana NNP (Neural Network Processor) will be focused on driving performance even higher, though Intel notes that standard performance metrics for deep learning don't tell the whole story, and has thus far not revealed any specific performance figures.

> "Raja Kudori's task may be to come up with fewer products delivering higher performance.

Intel's mobile Core processors will integrate AMD GPUs and HBM2.

The performance expectations for the Nervana NNP are high, and the retail products were slated to begin shipping by the end of 2017. Early hardware already exists, with Intel working to tune performance, and the results must be promising, because Intel also announced that Knights Hill, the 10nm successor to the current 14nm Xeon Phi line (aka Knights Landing), has been canceled. Knights Hill was slated for the Department of Energy's Aurora supercomputer, with a performance target of 180 PetaFLOPS, but the contract has been rewritten with a goal of being one of the first Exascale systems (capable of at least one ExaFLOPS) in 2021. Whether that will come via Nervana or some other product isn't clear, but it seems likely.

Given the growth in machine learning and supercomputing applications, where graphics technologies such as Nvidia's Tesla solutions are major competitors, part of Raja Kudori's task may be to unify the various solutions that Intel already offers, helping to come up with fewer products that deliver higher performance. Or perhaps Raja won't be doing much with the Nervana or Xeon Phi products, and will instead work solely to improve Intel's graphics IP. Regardless, Intel has made a lot of waves, and we look forward to seeing where this leads.

Jarred Walton has been a PC and gaming enthusiast for over 30 years.

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Alex Campbell

OPEN SOURCE

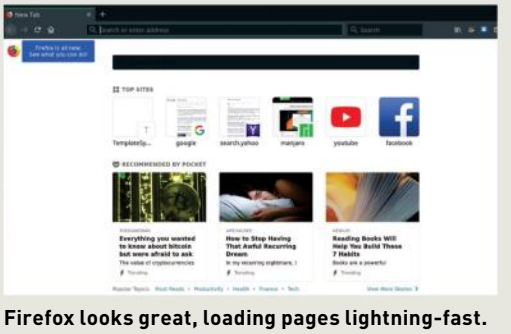
Firefox Is Back With Its Quantum Update

DEAR CHROME USERS: If you haven't tried the new Firefox, give it a go. Sure, some Chrome power users might not be convinced, but for privacy-conscious users who grit their teeth and use Chrome for its speed, Firefox 57 may upset the status quo.

Despite the drama surrounding operating systems, the web browser is central to today's computing experience. For most PC users, the majority of work and social media use, and media consumption is handled by a web browser. For the Linux community, this has meant using one of the two good defaults that come in most distributions: Firefox or Chromium.

For years, Chromium (and Chrome) have reigned supreme due to page loading speed and lower memory use. But while Firefox was slower than Chrome, Mozilla's browser focused on security and privacy. Users could be confident that telemetry data wasn't being fed back to Big Brother in Mountain View to be used to generate ad revenue. Firefox's solid base is implemented in the Tor Browser, for instance. But for some reason, Firefox was plagued by sluggish page loads and memory usage, that sent people scrambling back to Google's warm embrace.

On November 14, Mozilla released Firefox 57—or Firefox Quantum—for mobile and PC platforms. No longer wishing to play second fiddle, Firefox is now much snappier and easier on the RAM. Its blog says that contributors triaged some 369 performance-related bugs alone. The UI remains fairly minimalistic, though Firefox adopted a flatter appearance that helps unify the mobile and desktop experience. Speaking of desktop, Firefox 57 looks great on HiDPI screens on GNOME with Wayland.



Firefox looks great, loading pages lightning-fast.

One thing I find handy out of the box is Firefox 57's screenshot tool. If you've ever used a web clipper from Evernote or OneNote, Firefox's implementation will feel familiar, though much faster and more intuitive. Once you take a screenshot, you have the option to save it on your local machine or upload it. Once uploaded, it is publicly available on a Mozilla server for 14 days by default. You can set retention time to a custom value, or even make it permanent.

The screenshot tool integrates with Firefox's new library menu, which is a welcome addition. This combines quick access to Pocket, your downloads, history, screenshots, and bookmarks in a single menu. While this sounds busy, it's laid out pretty intelligently, and keeps toolbar clutter to a minimum. I haven't used a browser to save information for some time, instead opting for apps such as Evernote or Pocket for clipping and article saving. With this new functionality, Firefox edges into some of those convenience features, making it easy to save and recall information in your browser again.

While this update has a lot to enjoy, it falls short in one key area: There is little official support for offline or "standalone" Firefox apps. One of the coolest things about Chromium is that I can "install" a web app, such as Evernote or Spotify, add it to my application menu, and launch it in a standalone window (without tabs or a toolbar), so it feels like a native desktop app. Work has been done to be able to make Firefox compatible with Chrome apps, but the implementation is not as simple as it is in Chrome. Support for standalone Chrome apps is the main reason I will likely keep Chromium around.

I also noticed that Firefox 57 still mucked up my YubiKey authentication when logging into my Google account. After several tries, I had to start Chromium in Incognito mode just to see if it was a bad USB port, or if my YubiKey had gone on the fritz. Sure enough, Firefox couldn't handle Google's two-factor authentication. Logging into the LastPass extension presented no problems when the app asked for the YubiKey two-factor auth.

I have to say, I'm impressed with the new Firefox, and I'm looking forward to using it more as a daily driver. After all, if Mozilla's zippy new browser somehow manages to piss me off, Chromium will be there to pick up the slack.

Alex Campbell is a Linux geek who enjoys learning about computer security.

THE LIST

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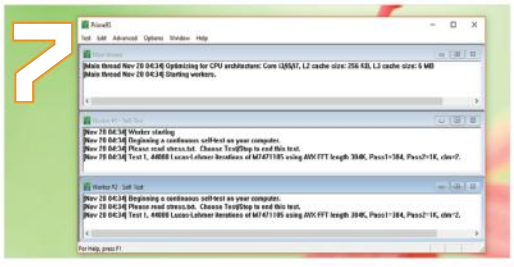
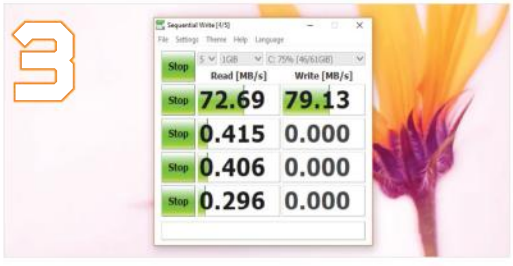


PRIME95 V2810 Stress-test every thread of your CPU by searching for Mersenne prime numbers—run it for at least 10 hours. **www.mersenne.org**

OCCT Check the stability of everything from your CPU to your power supply with a fearsome foursome of time-honored tests. **www.ocbase.com**

CINEBENCH Based on commercial renderer Cinema 4D, Cinebench's raycasting CPU test can tax up to 256 simultaneous threads. **www.maxon.net**

FRYBENCH A classic rendering test coded to both utilize every CPU cycle and hammer the cache to within an inch of its life. **www.randomcontrol.com**



CRYSTALDISKMARK Run this a few times, particularly on SSDs, as results vary depending on the random data generated. **http://crystalmark.info**

3DMARK TIME SPY 3DMark returns to our list with a DX12 benchmark that's a serious task for even the most recent GPUs. **www.futuremark.com**

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HEAD TO

BY ALEX COX

MP3 vs. FLAC vs. Ogg Vorbis

If you're ill-of-ears, you may never have considered the point in a serious audio smackdown between (arguably) the three major formats in digital tune management. But listen up: There's a lot to learn here. That dusty folder full of MP3s from the original Napster days? That's not the way music was meant to be heard, stored, or shared. So, let's pull apart those formats, and find the wins and losses in various categories, all while keeping the underwater garble of WMA at arm's length, conveniently ignoring the fact that it has a lossless version that's actually not the worst thing we've ever heard.

ROUND 1

File Size

For the most part, this factor isn't a major concern now that we're filling every available inch of our machines with an extra terabyte or 12, but your primary use of discrete audio files likely won't be on the desktop—it'll be on the move. And mobile devices, be they smartphones or the new generation of dedicated players, inevitably offer up pathetic storage options.

FLAC produces, by its nature, the largest files by far of the compression methods here. If you generate your own, FLAC files are typically smaller than directly copying a CD into a bit-for-bit WAV file, but not by a massive amount. The usual ratio is around 10:6. Expect a typical track to weigh in at around 30MB, although commercial hi-res files tend to trend toward far larger sizes.

MP3 and Ogg Vorbis are equally miraculous when it comes to squashing listenable music into a small space—tracks that are listenable tend to weigh in at around 4–5MB, depending on the encoder used to compress them, and the specific settings fed into it. Arguably, Ogg Vorbis offers the best quality-to-size ratio, but it's a rather subjective win.

Winner:
Ogg Vorbis

ROUND 2

Compression Format

FLAC's lossless compression can be hard to get your head around—how can the file size of music be compressed with no loss of sound quality? Think of it like ZIP compression; squashing office files together reduces their size, but you don't lose chunks of your PowerPoint presentation at the other end. Obviously, the fact that FLAC is digital means vinyl lovers will growl about the superiority of analog over the grainy waveforms of digital music, but FLAC's one-to-one replication means dedicated lovers of needles bouncing around in dusty grooves may question their direction.

MP3 and Ogg Vorbis put up a good fight. MP3's method of perceptual noise shaping (chopping out frequencies your ear can't hear) can compress audio by around 10–12 times without a noticeable loss in quality—you miss some subtlety, perhaps, but it's not the swirling mess of compressed WMA. Ogg Vorbis, if anything, does slightly better, using a different psychoacoustic compression method from MP3, and concentrating on quality ratings rather than bitrates, which can make tracks of comparable size sound significantly better.

Winner:
Ogg Vorbis

ROUND 3

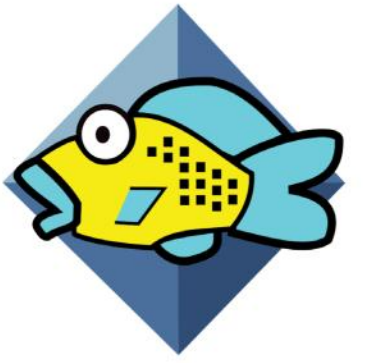
Freedom

Compressed music really came into its own with the popularity of MP3, despite a ton of other equally decent formats existing at the time. Blame WinAmp, the lousiness of WMA and RealAudio, and the fact that MP3 was easy to decode on the lesser processors of yesteryear. The problem is, MP3, for all its ubiquity, isn't free. Or at least, it hasn't been: The final patent is due to expire right about now, and Technicolor's licensing program for the codec ended in April 2017. There's now no need to illegally download the LAME encoder, no squabbles at trade shows, and the potential for MP3 to make a proper comeback. Not that it should.

The other two formats are both actually free. There's a clue in FLAC's name: It's the Free Lossless Audio Codec. It's free, as is Ogg. Both FLAC and Ogg Vorbis emerged from the open source community, and while they're both venerable (the various technical aspects of Ogg's bitstream format, for example, were frozen some 17 years ago), you're free to chop either protocol up and create your own format if you're a little bit crazy.

Tie:
Ogg Vorbis and FLAC

HEAD



ROUND 4

Resolution

Though technically lossy, MP3s encoded at 320Kb/s, 48,000Hz challenge all but the fussiest ears to pick out the compression; at the standard 128Kb/s or 192Kb/s resolution, though, MP3 creates a much flatter sound. Check out Ryan Maguire's experiments in rendering the audio lost in MP3 compression at http://vimeo.com/ryanmaguire for an audible example. Ogg Vorbis is also lossy, but if quality settings are pushed up during compression, it's much more adept at retaining subtle sounds. Both can employ variable bitrate encoding to maximize compression, with a little extra attention paid to complex areas.

FLAC is the king, and there's a good reason it forms the basis of most hi-res digital distribution networks. You can push it far beyond the limits of human hearing, and as it's lossless, beautiful compositions can't be ruined by audible artefacts. It's also built for accuracy; tiny errors in rendering are contained and don't ruin the whole track, and the checksums of compressed files can be compared against other copies to ensure they're absolutely correct. If you're not using FLAC, you're doing it wrong.

Winner:
FLAC

ROUND 5

Compatibility

MP3 has been around for a long time, and it's beyond rare for a device that supports audio playback not to support MP3—licensing fees and patents or not. There are MP3 decoder chips out there that can be tossed into all manner of electronics. Ogg Vorbis has moderately lower support, but only by a fraction—you might find a few Chinese players that can't manage it. FLAC is, by a small margin, the least supported format, although each FLAC file cleverly builds in the algorithm required to decompress it; so, barring DRM-locked tracks, future FLACs should play back on any device that currently supports the format.

It's also worth considering sharing. Digital distribution services such as Bandcamp demand a lossless format like FLAC on upload, since transcoding to a different format is relatively simple given a perfect master—so, if you're creating audio, FLAC is a must. However, podcasts tend to be distributed in MP3, because that's what most catchers/players expect, it can be squashed small, and the effect its compression algorithms have on the spoken word isn't quite as onerous as it is on music.

Winner:
MP3

And the Winner Is...

It's not a categorical win, because format use is a very subjective thing, but we're giving it to FLAC. It's well established, but flexible and powerful enough that it's poised to be the de facto audio format of the future, and if quality is your goal, there's no substitute for a lossless format. Ogg Vorbis's open nature is to its credit, and it's certainly capable of some serious quality, but it's always sat as an alternative rather than a leader—it's MP3 for those who wouldn't use MP3 because of its closed, patented nature. With that negative seemingly now crossed off the list, it's likely that Ogg Vorbis will fade even further.

MP3 itself probably isn't going anywhere, because it's perfect for a number of practical uses, but its position as a carrier for music might be endangered. Companies such as Amazon are unlikely to stop distributing it any time soon, but consumer demand is going to swing toward quality rather than file size, and we see FLAC moving in—particularly if labels think they can charge a little more for better quality audio.

DOCTOR

THIS MONTH THE DOCTOR TACKLES...

> Dual Antivirus?
> Graphics Upgrade
> Tricky Hardware

Troublesome Gear

Hi Doc, I have an issue with my PC, where its screen goes black and all its fans start spinning at maximum speed. The system stays like this and is unresponsive until I reset it. This seems to happen randomly; sometimes it goes black while I'm gaming, but I've also seen it act up at idle. I checked the CPU and GPU temperatures, and they look normal (low 30s C). I updated my graphics drivers, but to no avail.

Do you think this is a software issue, or related to hardware? I know the BIOS hasn't been updated, but I'm worried about the system crashing mid-upgrade.

Otherwise, the PC ran great since I built it in 2014. The only upgrade I added was a GPU about one year ago, and the problem started about four months ago. Any suggestions are appreciated.

The system includes a Core i7-4790K, an Asus Z97-Deluxe motherboard with BIOS 1008, an EVGA GeForce GTX 1080, a Samsung 840 EVO SSD, WDC Red hard drives in RAID 1, 16GB of Corsair DDR3, and Windows 10. **–Chris**

Check with EVGA to be sure your 1080 isn't affected by a faulty component.

THE DOCTOR RESPONDS: It sounds like this issue can be traced to your graphics card or the power it's receiving. One spec you left out was your PSU. But since the problem happens under load and at idle, it's probably not a lack of capacity.

In general, the Doc would advise double-checking the power connections to your GeForce GTX 1080 and motherboard, and ensure the PSU is connected to a quality surge protector or UPS. Worst case, try another power supply to see if the issue persists.

In this specific case, since you did mention owning an EVGA card, there's another possibility to consider. Last year, the company confirmed that a small number of 1080 FTW cards suffer this exact problem. It's caused by an ON Semiconductor VRM component operating out of spec, triggering over-current protection. If this turns out to be your culprit, EVGA should be willing to issue an RMA. Contact the company at support@evga.com to determine if your board might be one of the ones affected.

Should this clear up your stability issues, definitely update your motherboard's BIOS. Version 1008 was released in May of 2014. Asus has something like 12 newer builds posted to its support site, the latest from April of 2016, most of which mention improving system stability.

New GPU

Dear Doc, my wife and I just bought a new LG OLED TV (model OLED65C7P). My kids have a PS4 Pro hooked up to it, and I built a home theater PC about four years ago that I'd like to connect as well.

It contains an older AMD FX-8350 processor on an Asus Sabertooth 990FX motherboard, with 16GB of DDR3-1866 memory. A Samsung 850 EVO SSD has Windows 10 on it, while a 2TB WD Blue mechanical hard drive handles bulk storage duties. My power supply is a Turbo-Cool 860W. Currently, there's a Radeon HD 6950 graphics card installed, and I know it runs well at up to 1080p. I was hoping to reuse as much of that hardware as possible, but I know the GPU is going to be an issue.

I am a little confused about the TV's refresh rate, which LG claims is 120Hz. Of course, I want to make sure I pick the right graphics card to go into this computer. I play *World of Tanks, Fallout 4,* and *Call of Duty: Infinite Warfare,* as well as online Steam games. I'm looking for the smoothest experience possible with all of the eye candy enabled. My budget is 800–1,000 bucks, so I don't know whether I need one or even two graphics cards. Any advice you could give me, Doc, would be very much appreciated.

–Christopher Leach

THE DOCTOR RESPONDS: Your TV natively supports 1920x1080 at 60/120Hz or 4K at 30/60Hz input. Regardless of whether you're targeting the lower or higher resolution, though, a

↘ submit your questions to: doctor@maximumpc.com

substantial graphics upgrade over the Radeon HD 6950 is certainly warranted.

The latest generation of DirectX 12-based games and VR experiences have soured the Doc to multi-GPU configurations. He would rather buy the fastest single-GPU solution possible, and circumvent compatibility problems and issues with frame time variance altogether.

With that said, your budget leaves plenty of room for high-end graphics. GeForce GTX 1080 Ti cards start around $720. And in the games you're talking about, they should easily hit 60fps at 4K using cranked-up detail settings. If you'd prefer a lower resolution and higher refresh rate, one or two steps down Nvidia's hierarchy would probably be fine.

There's something else to think about, though. While reusing old hardware is commendable, graphics cards intended for 4K gaming are meant to be paired with capable platforms. More than likely, an FX-8350 is going to bottleneck high-end GPUs from AMD or Nvidia. You're better off diverting some of your budget toward a new Core i5 or Ryzen-based CPU, corresponding motherboard, and DDR4 memory. Then, snag something like a GeForce GTX 1070, 1070 Ti, or Radeon RX Vega 56 with what's left. The resulting combination should be much more balanced, enabling you to set aside the old configuration for another purpose.

Stranger Things

Hi Doc, I have been trying to fix an issue with a friend's computer, which came to me pretty much dead. So, I started troubleshooting. Since the power supply seemed fine, I pulled the RAM out and tried to turn the machine on. I got no response, not even a beep. I shut the system off and reinstalled its memory. Upon hitting the power switch, the PC booted up fine.

Please help me explain the cause of this issue, because it's baffling me. I think the motherboard is to blame, but I'm not sure. **–Jason Echelar**

ASRock's Fatal1ty X99X Killer is no longer top-of-the-line. Try an LGA 2066 platform instead.

THE DOCTOR RESPONDS: Although more information would certainly help the Doc narrow down your issue, this certainly sounds motherboard or memory-related.

Do you have the latest BIOS installed? It's common for updates to include optimizations for memory compatibility. Make sure the memory isn't overclocked from within the BIOS, which could cause it to exhibit intermittent stability problems. If you're using a dual-channel memory kit, try running with one module installed to determine if there's any difference between them. You might also want to try running MemTest86, which can help ferret out hard-to-replicate memory faults.

Building a Monster

Doc, I'll start off with a bit of flattery. I've been a long-time subscriber, and I remember the good ol' days when you had two versions of the publication (magazine alone, and another with an included software disc). But more importantly, I truly look forward to finding the magazine in my mailbox each month.

My question concerns a new rig I'm building. The components are coming together slowly, and currently include: an Intel Core i7-6900K, which I'd like to overclock to at least 4GHz, a Corsair H100i closed-loop liquid cooler, an ASRock X99X Killer motherboard, 64GB of G.Skill Trident Z DDR4-4000 (8x 8GB), a Crucial 512GB M.2-based SSD, a Crucial 525GB SSD for my operating system, a Crucial 1TB SSD for apps, two Toshiba 6TB hard drives in RAID 0 for user data, a GeForce GTX 1080 graphics card, a 1,000W power supply (haven't decided on the brand yet), and Windows 10 64-bit.

That's more or less the direction I want to go. I plan on getting back into video and photo editing, but am watching my money like everyone else. I did reach out to ASRock to see if the G.Skill memory kit would run at 4,000MT/s on my motherboard. But company representatives can only confirm a maximum of 3,400MT/s based on their internal testing. Overclocking the Core i7 to 4GHz should be easy, though.

I'm anticipating a price drop once the Skylake-X chips become available. Any possible info you can pass along would be appreciated and respected. If there's any way for you or someone else to test that memory overclock, even better. **–George Cora**

THE DOCTOR RESPONDS: As you no doubt saw, George, Intel's Skylake-X CPUs did have a big impact on pricing. This was almost certainly related to newfound competition from AMD and its Ryzen Threadripper models.

Today, you can get a 10-core Core i9-7900X for less money than the i7-6900K you were eyeballing. It's not an overclocking beast by any means. Intel's use of thermal paste between its heat spreader and die negatively affects thermal transfer performance, causing the CPU to run hot. But 4GHz shouldn't be too much of a challenge under a capable all-in-one liquid cooler. Alternately, Core i7-7820X gives you the same eight cores as the 6900K for $500 less.

Regardless of the CPU, don't worry too much about a 4GT/s memory transfer rate. Intel's high-end desktop platforms employ quad-channel configurations. At 2,666MT/s, you're looking at a theoretical peak in excess of 85GB/s. Jumping to a 128GB/s ceiling sounds huge, but your critical apps would need to be memory bandwidth-bound before you saw any advantage. Rock-solid stability is more important from a workstation, in the Doc's opinion.

Two Antivirus Apps?

I have been told to never install two antivirus programs on the same computer at the same time. Could this be achieved without issues if you keep the one you're not using zipped? I vaguely remember doing this years ago with a program I believe was called Oil Change. **–Bob McElwain**

THE DOCTOR RESPONDS: Security professionals agree that it's ill-advised to install any more than one antivirus utility at a time. Performance concerns are commonly cited. Even one security suite can tie up significant processing and memory resources. Worst case, they'd trip over each other's efforts. Not only do two antivirus apps have their own policies for dealing with bugs they find on your computer, but they might also see each other as threats.

Modern A/V apps typically get their hooks deep into your operating environment, and can't simply be compressed into an archive and tucked away. There is a handful of portable antivirus/malware scanners, such as ClamWin Portable, that you can download and save on to a thumb drive for manual detection. You wouldn't have them installed on your PC, though. Instead, they'd be part of an IT toolkit for diagnosing an infected machine.

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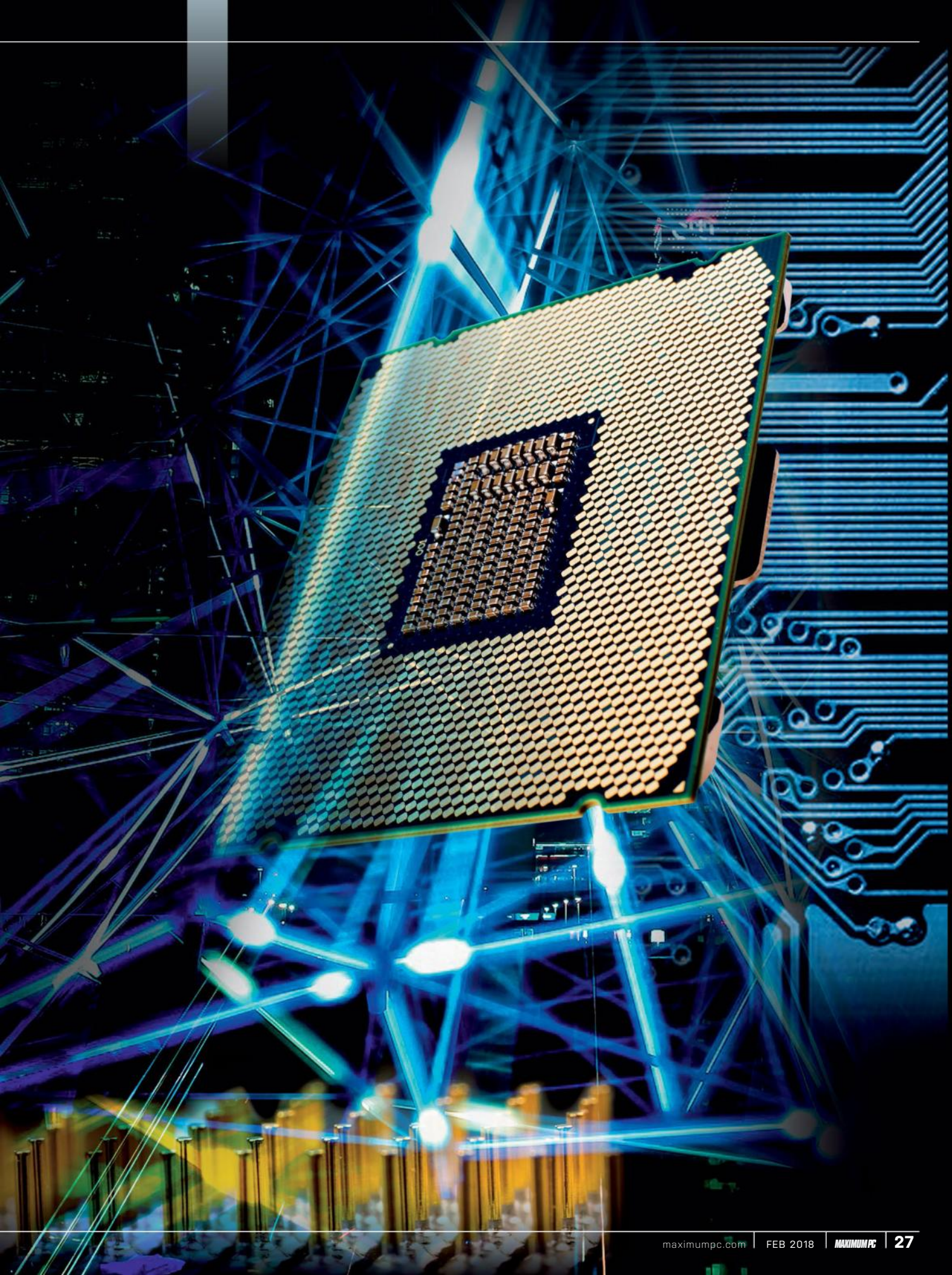
2018 TECH PREVIEW

Twelve months is all it took to see revolutionary change in the tech industry. With the race to greater core counts in mainstream processing, the release of Intel's Optane SSD drives, Ethereum mining pushing up GPU prices, and more, 2017 was a particularly interesting year. But that's in the past, and 2018 is the future, so what do the next 12 months look like? It's time to sift through the hype, and get down to the nitty-gritty of what is going to make 2018 great.

By the Maximum PC staff



REFINING SUCCESS

Intel may be rattled, but AMD needs to cement its success with revision

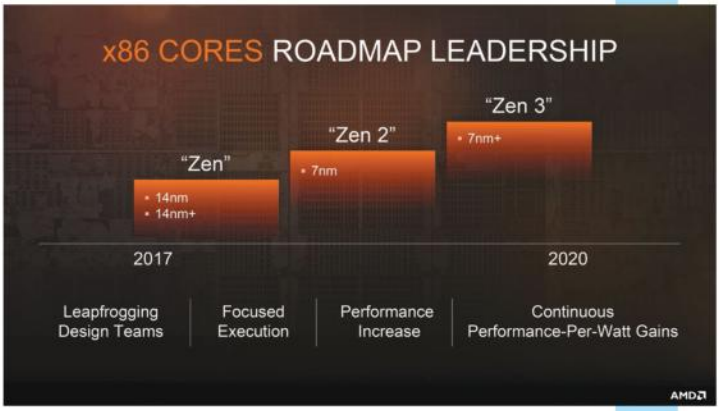
IT'S A RARE OCCURRENCE for the hype train to be not quite as overwhelming as the potency of the product it represents. And with Jim Keller masterminding the development of Team Red's latest architecture, AMD's Zen CPU lineup was hardly going to be a dud. However, none of us truly knew what to expect from the company that had otherwise disappointed us on the computational front for the previous six years.

Ryzen was, and still is, a masterpiece. A once-in-a-decade reinvention of a product. Something that AMD so desperately needed in order to assure its own future. Its effect on consumer computing has been vast and far reaching, pushing Intel to act, stop resting on its laurels, and raise its core counts higher, if only to retain anything like the market share it once had. And, at last, after six long years of waiting, there's finally a choice—consumers actually have a decision to make once again. Both processor manufacturers now provide options more than capable of succeeding the platforms of yesteryear. Whether it's Skylake X or Threadripper for workstations, Coffee Lake or Ryzen 7 in the mid-range, or Ryzen 3 or the Core i3s at the budget end of the spectrum, there's a processor for everyone.

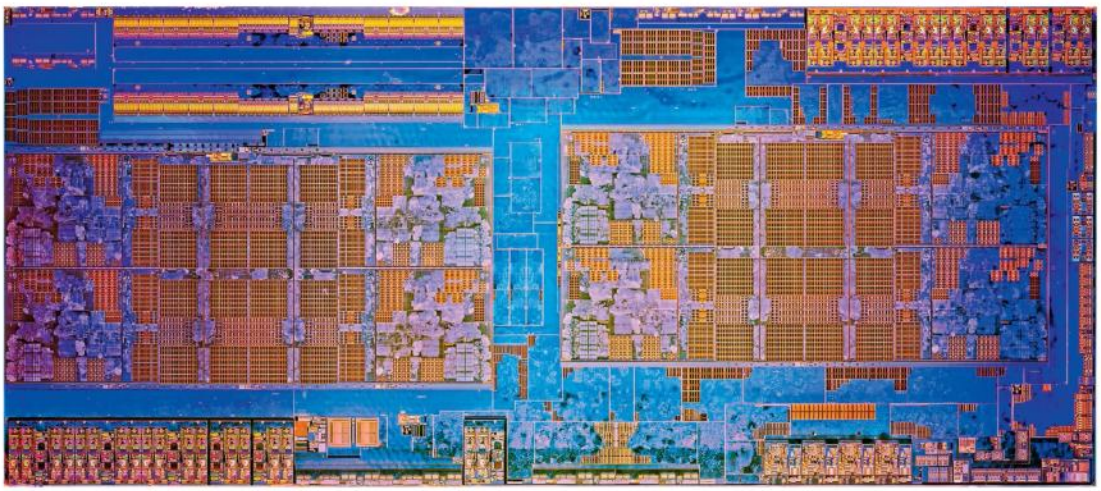
However, Ryzen certainly isn't perfect, and even Don Woligroski, AMD's Desktop CPU Marketing Manager, when speaking to YouTuber JokerProductions, stated that Ryzen was a "worst case scenario" for AMD. A new architecture on a new node brings up a whole plethora of issues, including memory and BIOS bugs, power draw woes, and overall lower frequencies than what were originally intended.

Ryzen 2, known as Pinnacle Ridge, looks to correct these issues. Rumored to be released some time in the first quarter of 2018, we're expecting a drop to a 12nm production node (down from Ryzen's current 14nm), higher base clock frequencies, lower power draw, and two brand new X470 and B450 chipsets to accompany the retention of the AM4 socket (allowing for backward compatibility with previous chipsets). All of which should bring up single-core performance to Skylake and Kaby Lake levels, and in turn enhance multicore performance as well. On top of that, it should also help refine the platform further, with enhanced memory support, better overclocking, and improved motherboard design, and potentially also allow AMD to introduce more PCIe lanes to its newer chipsets.

It would also be highly surprising if we didn't see AMD launch its range of Vega-powered Raven Ridge APUs some time around Q1 as well. Hopefully, they'll bring more options to those interested in building a budget-friendly low-spec gaming machine or media PC. Rumor has it, these should feature four Zen cores (or two Ryzen core complexes, with support for 8MB of L3 cache, and multithreading), and 11 Vega GPU cores, and should prove to be quite the beast at 1080p low to mid-range gaming.



Zen is only the start of what Ryzen has to offer.



The genius of Ryzen lies within its Infinity Fabric interconnect.

DECIPHERING INTEL'S NEXT GEN

What exactly does Intel's hunt for that elusive 10nm process node mean for us?

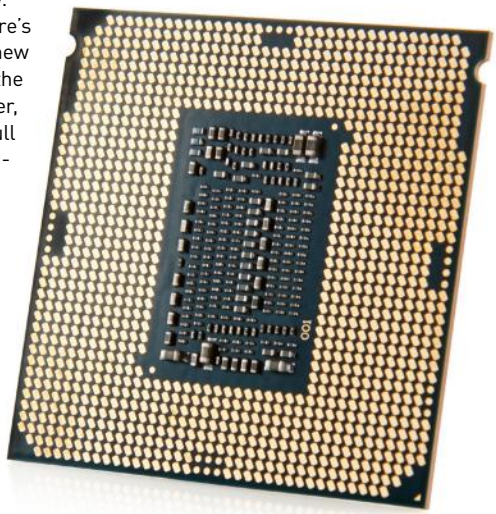
BUT WHAT ABOUT our dear Team Blue? Well, Intel's hardly out for the count—it still holds on to a massive chunk of that processor market share, and with that in tow, pumping more money into R&D is an easy task for the chip-making giant. Combine that with its Core architecture still being far superior to AMD when it comes to single-core performance, and all is not lost. Coffee Lake proved to us that Intel was willing to listen, and at last we've finally witnessed more cores piled into its smaller form factor chips. With the 1151 socket now hosting up to six cores and 12 threads on its highest Core i7 flagship parts, the future certainly looks bright for those looking to stick with Intel.

So, what's next? Well, Coffee Lake is Intel's fourth 14nm product, and the start of its eighth generation of processors. Although the company has confirmed that Coffee Lake is the last of its 14nm product line (not including the Kaby Lake R 14nm++ mobile refresh), confusingly, it's not the last of its eighth-gen chips. Cannon Lake will also fall under the same categorical nomenclature, even though it's a process shrink down to 10nm. Confused? You're not the only one. Typically, when Intel still ran its Tick Tock methodology, it would release an architecture, then shrink the process, with each step being a new "generation" of processors. Although Tick Tock was recently retired for PAO (Process, Architecture, Optimization, each step still being a new "generation"), Cannon Lake's 10nm process shrink still falls under the "Eighth" generation of processors, according to Intel.

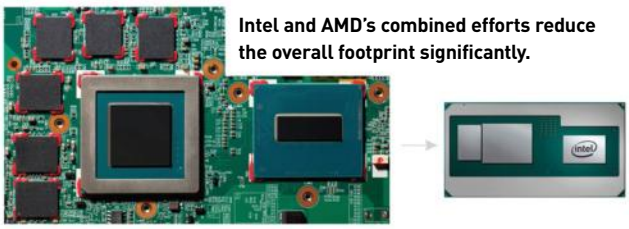
From this, we can predict two things. Firstly, that Cannon Lake's 10nm processors should be backward compatible with the Z370 chipset and socket; and secondly, that process shrinks will no longer be defined as a new generation, presumably indicating that a reduction in transistor size isn't providing Intel with the individual core performance boost that it was hoping for, with it more likely leading to reduced power draw instead.

That said, the drop to 10nm is intriguing, as it should reduce the overall size of the silicon die by 28.6 percent. Combined with a lower power draw, Intel should be able to incorporate more cores into its mainstream processors without increasing the size of its chip, or changing the LGA 1151 socket design too significantly. Intel has stated that it'll be producing a "lower volume SKU" of Cannon Lake early in 2018, before ramping up production within the first half of the year to full capacity.

Then, of course, there's the chipsets. Expect a new one (likely Z390) before the end of the first quarter, tapping into the full potential of these eighth-generation processors.



Coffee Lake makes six cores the norm for high-end Intel.



Intel and AMD's combined efforts reduce the overall footprint significantly.

In Cahoots?

IT WOULD BE REMISS of us not to mention AMD and Intel's recent partnership in bringing one of the world's first Radeon and Intel powered SOC Ultrabook combos together. The aim is to reduce the overall form factor of gaming notebooks, from the usual 26mm thickness to something more classy and compatible with the Ultrabook form factor, without compromising on performance. To do this, Intel's taking advantage of its EMIB interconnect to incorporate HBM 2.0 memory stacks, a bespoke Radeon GPU core, and its own Intel processors, to reduce the footprint of its internal componentry significantly. We've yet to receive confirmation as to whether this will be a Vega or Polaris powered GPU, but it looks promising.

EMIB is a multi-die interposer technology, which allows Intel to incorporate multiple individual dies, at varying processing node sizes, across a single substrate, in very close proximity. So, for instance, you could see a processor using a 10nm process, with a graphics core at 14nm, and the dedicated I/O chip at 22nm, all within a single millimeter of each other, without issue. This leads to a cheap, small-form-factor interconnect that reduces power draw, temperature, height, and cost, with very little difficulty for the partners involved.

We expect to see Ultrabooks powered by this new technology in the first quarter of 2018, potentially revolutionizing performance in the ultra-slim form factor sector of the industry.

EVOLUTIONARY GREEN GPUS

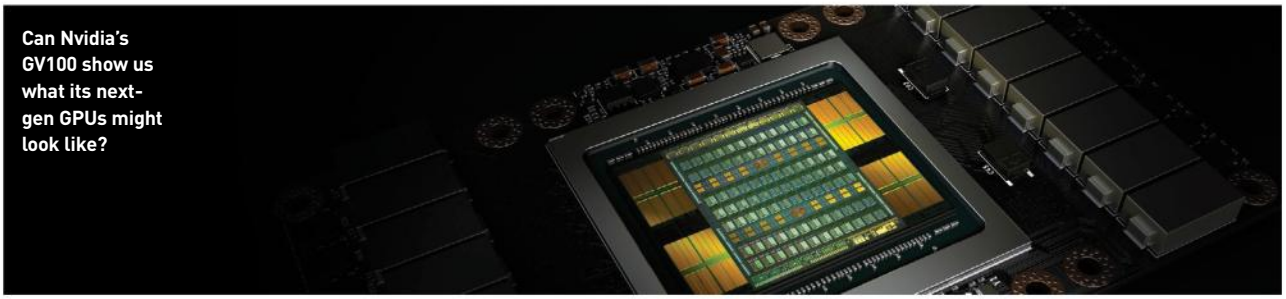
Is Nvidia's Volta architecture the revolutionary GPU we've all been waiting for?

IT WOULD BE FAIR TO SAY that Nvidia has demonstrated a good show of force when it came to the grand GPU war of the last two years. Pascal has been out for well over 18 months now, and still continues to reign dominant over its red competitor. Radeon's Technology Group simply hasn't been able to compete, either at the mid range, with its Polaris-based RX 400 and 500 series cards, or even more recently at the very high end, with Vega falling flat on its face, far from the hype that surrounded it. But with little competition, what's the next step for the great green giant?

Well, that would be Volta. We've long been hearing rumors about Nvidia's latest and greatest architecture finally making it to the consumer market, and it's only now that we have any inkling as to what it might actually include. We know that TSMC is manufacturing the core, we know that it's operating off the 12nm FinFET production node, and we also know that there are already enterprise-grade accelerator cards in existence—powered, of course, by the magnificent might of the GV100 core. So, what can we expect from this new GPU lineup when it actually does launch consumer-side?

We can't say for certain, but looking back at the past may give us a clue. We know the number of CUDA cores found on both the current Pascal P100 GPU accelerator and the GTX 1080 Ti are the same. If that's the case, it's likely that Volta's V100 and the consumer-side 2080 Ti (whenever that launches; think 2019) will be identical. We can then calculate the percentage difference between the CUDA cores on the GTX 1080 Ti and the 1080, apply that to the V100's spec, and come up with a rough estimate of just how many additional CUDA cores Nvidia's next-gen flagship (the GTX 2080) might hold. The short answer is that it's a 33 percent increase in CUDA cores, and therefore pure GPU grunt over the last generation, and that's not including any architectural magic, or transition across to GDDR6 or HBM memory. A 33 percent minimum increase in brute force performance, which is exciting enough, if current price points hold across the generational jump.

Nvidia's co-founder and CEO Jen-Hsun hasn't stipulated that we should expect an immediate response to Vega, so it's unlikely we'll see these cards before the first quarter of 2018. However, with SK Hynix's recent announcement of its latest GDDR6 memory standard being produced for high-spec cards already, and Volta enterprise-grade GPUs now being available to the public, we'd be very surprised if we didn't see these launch before or at Computex 2018.



Can Nvidia's GV100 show us what its next-gen GPUs might look like?

HBM vs. GDDR

THE BATTLE for VRAM dominance needs settling this year. With both Nvidia and AMD utilizing GDDR5X and HBM 2.0 in their product lineups, which is best, and what will we see on the GPUs of tomorrow?

Each has its advantages and disadvantages. HBM 2.0 takes up less PCB space than typical GDDR5X stacks, runs at 1.2V, has an incredibly low latency, puts out an astonishing amount of bandwidth (242GB/s per stack versus GDDR5/X's 44GB/s), and, more importantly, features Pseudo Channel mode, which splits a memory channel in two, with one pseudo channel dedicated to memory reads, and the other to writes. Think of it as multithreading, but for memory, and solely dedicated to read and writes, as opposed to processes.

That said, it has issues: It's expensive, in short supply (with only Samsung and SK Hynix currently producing it), and can be difficult to design new GPUs around, especially if the GPU in question is used across a range of cards, at different price points, such as the GP104, which covers the GTX 1070, 1070 Ti, and 1080.

GDDR5X did address some of the discrepancies between the two standards, especially from a bandwidth perspective, and only then when competing alongside more consumer-friendly dual-stack Vega GPUs. However, latency is still an issue, and it lacks any form of multi-channel support. Which is why Nvidia currently incorporates HBM 2.0 into its

Vega was disappointing, but Navi should correct its mistake, and step away from the underwhelming GCN architecture.

AMD ON THE BACK FOOT?

Team Red needs Navi, and it needs it now

IT'S BEEN A ROUGH YEAR for AMD's Radeon Technologies Group. A really rough one. We didn't expect the slightly bashful underdog of GPU technology to produce anything astounding, but after delay, after delay, after delay, we did expect more than we ended up with. Vega feels very much like a dud, especially as far as gaming is concerned. And although it powers through crypto-mining like a V8 through gasoline, when your flagship card can't compete with a competitor's 14-month-old solution in the things that really matter, you know you've got problems.

Combine that with the departure of Raja Koduri, AMD's Radeon Tech Group Leader, leaving for Intel, from the outside, at least, things look dire. But are they really? We doubt Raja would have left if things with AMD's next-gen architecture weren't already shored up. And much like Jim Keller leaving before Ryzen made it to market, there's the likelihood that Navi itself may also be finally on its way to completion, with the initial design stage out of the way. Sources suggest that AMD may indeed showcase one of its Navi GPUs at 2018's SIGGRAPH event around August this year, with a full commercial release coming at the end of 2018.

So, what can we expect from the new architecture? Well, there are two exciting things to consider here. Firstly, there's the drop to 7nm. Secondly, there's AMD's recent development of its new interconnect, aka Infinity Fabric. What does that mean? In short, Vega currently operates off the 14nm manufacturing process; 7nm equates to a 50 percent increase in the overall number of transistors and, in turn, stream processors. On top of that, with AMD's Infinity Fabric, we may see the end of old-school monolithic GPU dies from the company. Instead of having one hard-to-manufacture, massive GPU die, as we've typically seen from GPU makers, AMD could do something similar to how it produces its Threadripper and Ryzen processors. In brief, smaller, less complicated GPU core complexes, with an interconnected fabric bridging performance between them, without increasing the complexity or cost of manufacturing the processors themselves.

It's worth noting that both AMD and Nvidia are looking to move away from the monolithic designs, as dropping down to the next process node becomes too taxing a task to achieve in the current climate.

Although we have no way of quantifying what kind of performance increase we could see here, the notion of adding more cores, at a fraction of the complexity and cost, may make Navi AMD's saving grace, and is certainly interesting when it comes to the future of GPU development.

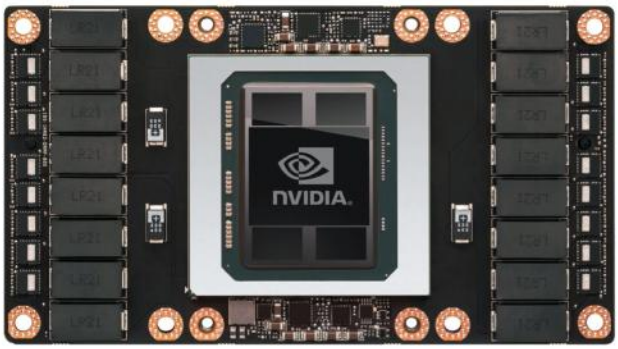
But what about that 14nm+ refresh we keep hearing about? Well, our bet is we'll see a 14nm refresh of the RX 580, Vega 56, and 64, with a new low-power manufacturing process, being rebadged as new mid to high-end GPUs, followed by one or two Navi 7nm cards in the same generation being the flagships with the new designs.

HBM isn't only seen on AMD-powered GPUs, but Nvidia ones, too.

high-end Tesla cards available today.

Fortunately, Micron has announced that it's mass-manufacturing GDDR6 modules, to be utilized by high-end GPUs early next year. GDDR6 garners a 4Gb/s bump in memory transfer speed, and, more importantly, also features dual-channel support, which could help combat HBM's Pseudo Channel mode.

For the time being, it seems we'll still be stuck in this memory hierarchy, with GDDR5 and 5X featuring on more budget-friendly cards, GDDR6 on the high end, and HBM typically utilized on Vega and more workstation-oriented variants instead.



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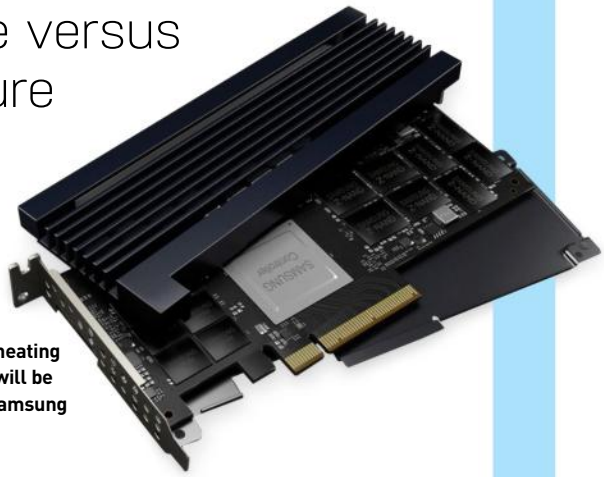
STORAGE SUPERIORITY

Intel versus Samsung, Optane versus Z-NAND, in a fight for the future



The battle's heating up, but who will be the victor? Samsung or Intel?

THE STORAGE WARS have been waging for quite some time now. Samsung's 960 series PCIe SSDs have comfortably sat top and center of the non-volatile hill for the last 12 months. And with little challenge to the Korean giant, there's been no need for the company to reveal any new devices designed to push the boundaries of solid-state storage further. Even Intel and Micron have struggled to put up any resistance to the dominance of Sammy's 3D MLC V-NAND tech and its controller—at least, not until recently.

And then there are the connection standards, or perhaps it's more apt to just say M.2 at this point. Because that's the only connection standard still worth its salt in the PCIe board game. Intel's U.2, like many—if not all—closed-off proprietary connection standards, has fallen by the wayside, with lots of motherboard manufacturers no longer supporting it. With few devices operating on the standard, and the price-to-performance of Intel's 750 SSDs being less than desirable, there just wasn't enough choice to see it used enough.

This year hasn't been a complete dud for storage tech, though. Intel and Micron's design teams have finally brought the true might of their Optane 3D XPoint memory technology to market. First in the less-than-stellar Optane cache M.2 sticks, then in the phenomenal power of the 900P series SSDs. Although sequentials were lower than the competition, the stellar low latency and incredible 4K random reads and writes made it leaps and bounds more powerful than the prestigious 960 Pro.

Intel has promised that there's more to come from the fledgling resistive tech, but for the time being, the battle seems to be shifting away from how fast a sequential figure you can get, and more toward low latency and higher IOPs. Samsung is well aware of this, too, recently announcing the launch of its Z-NAND consumer SSDs.

Z-NAND is, as far as we know, a derivation of Samsung's 3D NAND technology. Still built off the existing 40nm processing node, it's expected to feature a brand new controller, and a single-level cell design, as opposed to the 960 series multi-level cell. In short, the more data you store on a single bit of V-NAND both increases its latency and reduces the number of total read and write requests possible on the cell itself. SLC is far superior, but comes at a far greater cost and, unfortunately, lower density, meaning a larger PCB and, ultimately for Samsung, a PCIe add-in card, much like Intel's 900 series drives.

Although, for the time being, Z-NAND is enterprise only, we do have some figures for the drives, which can give us a bit of an idea about where the consumer equivalents will sit. Samsung revealed that both sequential read and write speeds will operate at 3.2GB/s, compared to Intel's 2.4GB/s read and 2GB/s write; random read IOPS will be up at 750K versus Intel's 550K; write IOPS will be 170K versus Intel's 500K; random read latency should be around 12–20 microseconds, compared to Optane's 10 microseconds; and, lastly, the random write latency will be 16 microseconds versus Intel's 10. Although not competitive across the board, if Samsung's drives arrive at a significantly lower price point than Intel's (because they rely on already well-established technology), they could render Optane redundant, unless you need it for very specific use case scenarios.

There's not been any confirmation of exactly when we expect to see a Samsung Z-NAND consumer drive appear, but we do expect these to drop some time during the first half of 2018.

Intel takes the advantage as the storage wars shift away from sequentials, and toward lower latency devices instead.

SPECIFICATION	Samsung Z SSD (SZ985)	Intel Optane (P4800X)
Technology	Z-NAND	3D XPoint
Capacity	800GB	750GB
Sequential Read (GB/s)	3.2	2.4
Sequential Write (GB/s)	3.2	2.0
Random Read (IOPS)	750K	550K
Random Write (IOPS)	170K	500K
Random Read Latency (µs)	12–20	10
Random Write Latency (µs)	16	10

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THE FUTURE OF DISPLAY

Is 4K the new mainstream?

Bear in mind that Asus, AOC, and Acer's 4K 144Hz panels are made by the same manufacturer.

AS FAR AS SCREEN TECH is concerned, we've stagnated over the last 12 months. Although HDR was promised as the "next big thing" from manufacturers across the globe, its impact on the computing industry has been stifled. With quantum dot, OLED, and RGBW panels occupying the price point they do, and a lack of HDR content making it into the mainstream, the desire to invest in the new tech has been slim. Much like 4K before, it's taking time for the uptake of both content and screens to occur.

Speaking of 4K, not a lot has changed in this arena either. Panels have reduced in cost as more manufacturers bump up their production lines, and we're starting to see an abundance of screens pushing the 30-inch barrier, but apart from that, 2017 has been relatively quiet. We've not seen as much of an uptake into 1440p and higher resolutions as was expected, so development has tended to focus around higher refresh rate monitors instead.

Which segues nicely into a discussion of where we're going in the future. So, what can we expect from 2018? Well, as far as flagships are concerned, we're expecting high-refresh 4K panels to finally arrive. Although DisplayPort has been capable of handling 4K at higher than 60Hz since way back in 2014, as far as GPUs are concerned, it's been nothing more than a far-fetched fantasy. AMD's RX series GPUs and Nvidia's GTX 10 series were the first to support DisplayPort 1.4, enabling enough bandwidth to go beyond 60Hz at 4K. Technically, DisplayPort 1.3 supported that, but not with HDR as well. In 2018, Asus, Acer, and AOC are all producing 120Hz-plus 4K screens with HDR by default. We expect these to launch early in the year, presumably after CES. However, it's likely that these will be priced out of the stratosphere, with most probably retailing close to the $2,000 bracket.

Although not realistic for the majority of us, this does give us hope that the next generation of 4K screens will come down in price. Combined with more powerful, more affordable GPUs, the dream of an affordable 4K gaming combo is inching ever closer.

VIRTUAL RENAISSANCE

Does the resurgence of virtual reality lie with the next generation of headsets?

AHH, THE JILTED LOVER of the computing world. The buzz word that was on every journalist's lips. Was VR just another gimmick? Or was it misrepresented? Ahead of its time? It's difficult to say for sure, as sales have been reasonable, with both Oculus and HTC profiting from the VR experience, but little has come out of 2017 with regard to the new way of consuming media.

There have been price drops, for sure, with both platforms being reduced by a total of $200. And there's plenty of content, too, from an army of indie developers, and other games being made VR-compatible (there are 266 games and experiences currently listed in Steam's Virtual Reality category).

But the headsets still have problems. The 2160x1200 (1080x1200 per eye) resolution, so close to your eyes, still features that visible screen door or grid effect, and the refresh rate is still locked to a nauseating 90Hz. Ideally, we need to see a pixel density two to three times greater than what we have today before VR becomes more akin to gaming on even a 1080p screen. However, with Oculus announcing it won't be releasing a Rift 2 any time soon, and with HTC's latest Vive Focus concentrating on mobile, it's unlikely we'll see these changes make their way into the consumer ecosphere in the near future.

All that aside, early last year, Samsung's screen manufacturing division showcased a new display designed specifically for VR headsets. Cramming an incredible 2024x2200 resolution into a 3.5-inch form factor, it added over 86 percent more pixels into the same space. That's a pixel density of 858, versus the 460 of the original.

Perhaps 2018 will be the year when we finally see someone outside of the HTC and Oculus community bring a headset to market that actually makes sense for the graphically aware consumer. Or, better yet, see Microsoft's AR HoloLens project reach a more affordable level than the $3,000 price tag it's currently associated with.

Although exceptionally interesting, AR is just too pricey right now to justify.

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RESURRECT YOUR GAMING CLASSICS

Want to run old games on new Windows? Here's how

YOU PLACE A TREASURED CD-ROM into the disc tray, wistful about the good old days, and excited to see the familiar pixels of an old favorite game. Your PC reacts like a dog watching a magic trick. Autorun doesn't work. Setup.exe doesn't work. InstallShield is looking for a long-forgotten Windows 98 library file in perpetuity. In a very real and upsetting way, your childhood is no longer compatible with the modern world, and you know that the only way to rekindle it involves hours of compatibility box-checking, Googling, and fiddling. A traumatic moment.

But it doesn't have to be. Getting software that was designed for much older operating systems and hardware to run on modern machines offers its own intrinsic satisfaction. It's like breaking the rules, somehow, raising dead software that was never intended to interface with silicon this powerful, and bending an operating system to your will. There are many different avenues to pursue when you're attempting to do so, and that in itself has its own pros and cons. That variety of approaches means it's unlikely you'll truly reach a dead end, to stretch that avenue metaphor to breaking point. But it does also mean the plethora of conflicting information found on message boards suggesting this method or that can make this a tricky task to go about in a methodical manner. So, let's do exactly that: Let's turn what would ordinarily be an evening of directionless trial and error into a scientific process. The definitive and exhaustive guide to running old games on a new PC.

Lab coats are optional, but a willingness to install a few programs on your PC and a sound awareness of abandonware law are mandatory in this test environment. With those humble tools, you should be able to run any old game on a Windows 10 PC, however categorical the error messages seem upon the first attempt.

PHIL IWANIUK

BEFORE GETTING STUCK into the many-branched methodology of old game necromancy, let's examine why this problem exists. After all, if a PC can run *The Witcher 3* at a dreamy 60fps, why does it struggle to render 1999 tactical shooter *Rainbow Six: Rogue Spear* at anything above single figures? And why is it so hard to get certain games even installed?

Essentially, it all comes down to operating systems. Whenever a piece of software or PC game is developed, its creators make a series of assumptions about the environment it'll be used in. The developers of 1999, for example, might reasonably have expected that most users would be installing their game on to a Windows 98 or Windows 95 PC, both based around the 16-bit DOS operating system. That, in turn, means an assumption about the file libraries and drivers contained within those operating systems, and the kind of hardware that might be running it. Those developers couldn't anticipate that later versions of Windows, from Win 2000 onward, would only emulate DOS, rather than running it natively, and that the code that installs and runs the game on DOS-based operating systems would eventually become gibberish to Windows 10. And they couldn't have known—how could anyone?—what a monumental pain in the posterior UAC would prove in later, more security-conscious Windows iterations.

Generally, then, programs don't work on modern machines because those modern machines are running a recent OS. Hardware tends to play only an indirect role in incompatibility. For example, because 32-bit systems recognize only a 4GB maximum of memory, most of us run 64-bit operating systems to accommodate more RAM. But unlike 32-bit versions, 64-bit Windows doesn't include 16-bit emulation. That means it can't fool a Windows 95 application that's searching for recognizable libraries in order to install itself correctly. The same goes for today's graphics cards and processors: It isn't that they're inherently too powerful for old software, but that the old software can't interpret and harness their power correctly, because they don't understand the drivers installed.

The stumbling block for one particular vintage game might be DOS, driver support, missing libraries, security issues, or incompatibility beyond 16-bit systems, but the root cause is fairly universal: It's the software environment. The obvious solution is to modify that software environment so the old game has enough information and security privileges to function. And that's something you can go big or small with. Since we're doing this methodically, it makes sense to begin with the small measures, such as patches and DOSBox, and work up to more drastic solutions, such as running a virtual Windows XP machine.

SCOUR FOR UPDATES

If a game installs on your PC but won't run, first check online for official developer patches, and unofficial patches created by users who experienced similar issues. Perhaps you'll strike lucky with a game like *Vampire: The Masquerade—Redemption.* First released in 2004, it's long since been regarded as a cult classic, but shipped with more bugs than a mail order ant farm. Developer Troika was still releasing patches for it five years later, and the community took it even further with an unofficial patch, which still receives updates in 2017. Try the original disc, and you'll have problems, but with those two downloads, it runs perfectly on Windows 10.

Elsewhere, community modders have addressed issues pertaining to entire game engines, fixing a whole suite of titles in the process. Black Isle's Infinity Engine hosted many of role-playing's all-time greats, such as *Baldur's Gate I* and *II, Icewind Dale,* and *Planescape Torment,* but relies on Microsoft's defunct DirectDraw API, and thus has all manner of issues on modern machines. Aqrit's DDrawFix resolves those issues in nine games with one 5MB download. There are other solutions, but this is certainly more elegant than running an entire OS in a virtual machine just to access DirectDraw.

COMPATIBILITY MODE OPTIONS

Windows doesn't have a great reputation for the efficacy of its compatibility mode, but in certain circumstances, a checked box here and a drag-down menu option there might be all it takes to solve your problem, whether it be installing or running the old game in question. When you right-click on a program or installer, and navigate to the compatibility tab, you'll see several options to emulate different Windows versions and alter display settings. When you run an application in compatibility mode, you're telling your current version of Windows to lie to that application, and it does so by placing a layer of alternate code, known as a shim, between the application loader and Windows. File paths are translated from new to old, so C:\Users\You\Documents becomes C:\Documents and Settings\You\My Documents. It modifies the functions of certain .dlls so the application returns the expected information. For example, the GetVersionEx function used to determine which version of Windows an application's working with would return data from the shim, rather than the true kernel32.dll's information. In other words, when the application asks "Which version of Windows is this?" compatibility mode steps in and says "Windows XP, honest!" before your actual OS has chance to blurt out "Windows 10," and give the game away.

In reality, setting the right compatibility mode options can often be part of the solution, but it's rarely your one-stop

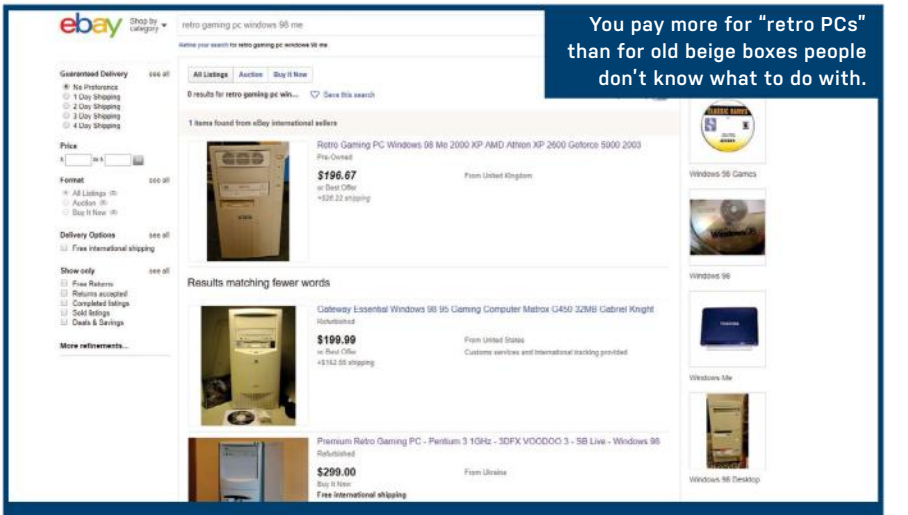
1996's *Tomb Raider* was among the first games to need a discrete graphics card, so it's hard to run in a virtual environment.

shop. As a rule of thumb, it's best to start by selecting the predominant OS at the time the game was released (Windows 98 for *Half-Life,* let's say), and running as an Administrator. This helps the application do what it needs to without Windows stepping in and halting it at an unexpected juncture. From there, you can experiment with 256 colors and 640x480 resolution limiting, but it's often best to move on and look for other solutions, rather than troubleshooting exclusively in the compatibility tab.

DOS AND DON'TS

Paradoxically, the further back you go with PC games, the easier it becomes to run them on modern machinery. That's in large part thanks to DOSBox, which emulates an Intel x86-based system, complete with graphics and sound cards, mouse support, and a modem. DOSBox should be the first port of call when running any pre-Windows XP game, which means it opens up about 20 years of gaming, from the *Commander Keen* days to late-nineties gems designed for DOS-based Windows. Since it's effectively a virtual machine, and you probably don't have a floppy disk drive in your machine, you need disk image files of the games you want to play. DOS games are generally considered abandonware now, so although it isn't legal to download them, it isn't likely to get you into trouble (see "Abandonware, all ye who enter" over the page).

DOSBox works by mounting a virtual C drive created by the user, then navigating around using command prompts. For example, C:\DOSGAMES becomes your DOSBox's virtual root drive with the command line "mount c c:\dosgames." For convenience's sake, it's worth keeping all your DOS game image files within this directory, each in individual folders. The "cd" command changes directory, which means you can type "cd [game name folder]" to navigate to your chosen game, then type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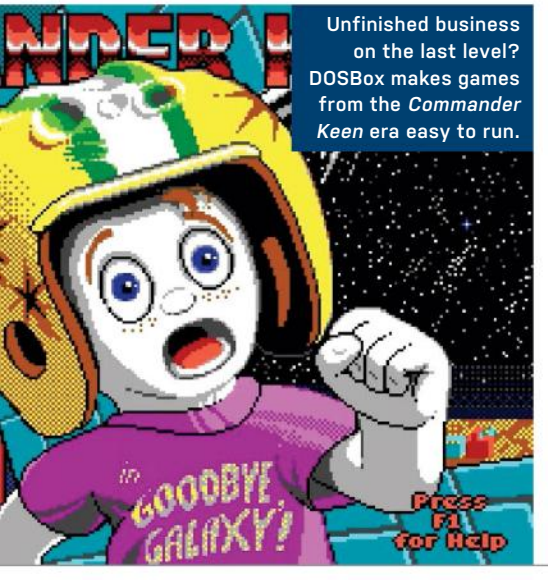
You pay more for "retro PCs" than for old beige boxes people don't know what to do with.

DOING IT THE HARD WAY

Depending on your motivation for coaxing an old game back into operation, simply getting it up and running on your current machine might not satisfy. A 4K HDR display might do wonders for your Steam library, but it only serves to highlight the shortcomings of a game designed to run at 640x480. And there's something a bit strange about playing *Quake* with an RGB mechanical keyboard and a wireless mouse, when all's said and done. When you feel that the modern technology ensconcing your old software is detracting from the experience, there's only one thing for it: a retro gaming PC build.

A word of warning, though: This can be costly if you're not smart about it. Perhaps it's not a big surprise that giant beige boxes with Pentium IIs and Voodoo 2s are a thriving cottage industry on eBay—everyone has one in their attic or garage, and for some people, the only way to enjoy old games is in situ. But their appetite for tobacco-yellowed Dell keyboards has driven prices well beyond what one might reasonably expect, so avoid searching specifically for "retro gaming PC" items. If you instead search for "Windows 98 PC," for example, you'll find listings for near-identical machines that don't carry a premium for their trendy vintage appeal.

It is worth buying entire PCs in one package, though, rather than trying to source everything component by component. Unless you've been reading up on motherboard/CPU/RAM/GPU compatibility of yesteryear in your spare time, it can be a nightmare to find parts that play nice with each other, or even function at all. Lastly, if you're buying a CRT screen, look for photos of it in operation to check it hasn't demagnetized over time.



Unfinished business on the last level? DOSBox makes games from the *Commander Keen* era easy to run.

Rogue Spear is in an awkward time bracket: too old for Win 10, too new for DOSBox. Still, there are ways to coax it alive again.

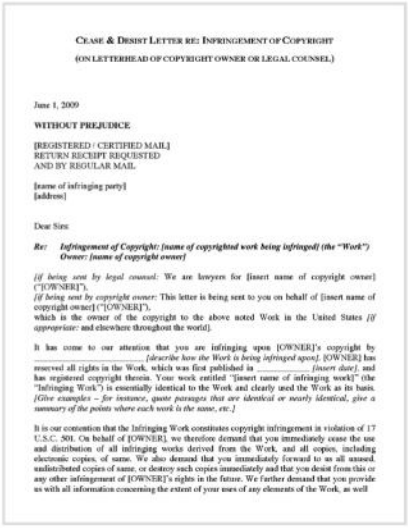
Sid Meier probably isn't going to turn up irate at your door when you download *Civilization I*.

ABANDONWARE, ALL YE WHO ENTER

Before even beginning to wrestle it into working, the act of acquiring an old PC game can be tricky in itself. Physical media drives are an increasingly rare sight on modern machines, and there's every chance you threw all your old games out years ago. It might be tempting to hunt for a disc ISO file of some forgotten treasure on an abandonware site, but before you do, it's worth knowing the legality of those actions, and what the term abandonware means.

Essentially, the term defines a legal no-man's-land in which a product's copyright might not have expired, but since its owner no longer supplies it for legal purchase or supports it, it "abandons" copyright enforcement. It's safe to assume Activision doesn't have a legal team pursuing all those who download ISOs of its 1998 shooter *SiN*, for example, but that doesn't mean it's legal to do so. Real-world example: Since Microsoft officially stopped supporting Windows XP in 2014, numerous sites have offered it for free, and none has faced legal action.

So, if you own a physical copy of a certain abandonware game, but no longer have a CD-ROM drive with which to install it, you're still not technically within your rights to download a cracked version online. But since it can't be purchased new elsewhere anymore, the copyright holder is unlikely to penalize you. If the company that holds the copyright no longer exists, you're on even safer ground, and if the original software was distributed under a shareware license (like the first third of *Doom*), well, the feds probably aren't tailing you day and night and preparing to haul you off to San Quentin. Shareware is fine. The important thing is to check whether something really is abandonware before downloading.



CEASE & DESIST LETTER RE: INFRINGEMENT OF COPYRIGHT
(ON LETTERHEAD OF COPYRIGHT OWNER OR LEGAL COUNSEL)

June 1, 2009

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RETURN RECEIPT REQUESTED
AND BY REGULAR MAIL

[name of infringing party]
[address]

Dear Sirs:

Re: Infringement of Copyright: [name of copyrighted work being infringed] (the "Work")
Owner: [name of copyright owner]

[if being sent by legal counsel: We are lawyers for [insert name of copyright owner] ("[OWNER]").
[if being sent by copyright owner: This letter is being sent to you on behalf of [insert name of copyright owner] ("[OWNER]"),
which is the owner of the copyright to the above noted Work in the United States *[if appropriate:* and elsewhere throughout the world].

It has come to our attention that you are infringing upon [OWNER]'s copyright by _____ *[describe how the Work is being infringed upon]*. [OWNER] has reserved all rights in the Work, which was first published in _____ *[insert date]*, and has registered copyright therein. Your work entitled "[insert name of infringing work]" (the "Infringing Work") is essentially identical to the Work and clearly used the Work as its basis. *[Give examples – for instance, quote paragraphs that are identical or nearly identical, give a summary of the points where each work is the same, etc.]*

It is our contention that the Infringing Work constitutes copyright infringement in violation of 17 U.S.C. 501. On behalf of [OWNER], we therefore demand that you immediately cease the use and distribution of all infringing works derived from the Work, and all copies, including electronic copies, of same. We also demand that you immediately forward to us all unused, undistributed copies of same, or destroy such copies immediately and that you desist from this or any other infringement of [OWNER]'s rights in the future. We further demand that you provide us with all information concerning the extent of your uses of any elements of the Work, as well

This is a copyright infringement notice. Get clued in on abandonware rules to avoid seeing one in the flesh.

the executable name to run it. Of all the methods available, DOSBox is one of the easiest and most reliable, and only requires a few command lines to get things up and running. Its limitations make themselves apparent when running 3D games that were considered demanding at the time, such as *Tomb Raider*, *Quake*, or *Carmageddon*. DOSBox runs these using its own software renderer, so for more advanced graphics, you need to seek out a 3DFX/Glide emulator designed for use in DOSBox. Some custom builds of the program, such as DOSBox SVM Daum, come with Direct3D, Glide, and other advanced features baked in, so are the best bet for running later DOS games that made use of graphics cards. Ah, the Voodoo days—brings a tear to the eye. And just to hammer the point home, don't rule out DOSBox if you're trying to run a game that was released for Win 95 or Win 98—they were DOS-based OSes, after all.

VIRTUAL INSANITY

If you want to take this vintage gaming thing to a greater extreme, it's time to consider running a virtual machine with an older OS installed. Broadly, this isn't too different an approach from running DOSBox, but if you find yourself playing a lot of games from that awkward post-DOS, pre-Win 7 era, it might end up being more convenient. Plus, there's the heady nostalgia hit of seeing the old OS's desktop, and enjoying all the sound effects—remember when performing almost any action on a PC came with its own bespoke sound effect?

VirtualBox is the go-to application for this. It's relatively easy to install even dusty old Windows 3.1 on a virtual machine, complete with the required

They really were the salad days, weren't they?

Classics like *Doom* don't need much to get running, thanks to Steam and community patches. Mouse support—what a treat!

virtual hardware, although you either need an install disc and product key for the OS, or a disk image. Once again, we're in the murky waters of abandonware here, but you can find Windows XP and older versions for free online, and Microsoft hasn't pursued any legal action against their distribution.

It's certainly preferable to be greeted by a familiar old interface when booting up games than it is to deal with DOSBox's black and white prompt windows, but VirtualBox does have something of an Achilles heel: 3D graphics support. Its native support is "experimental" (read: doesn't really work with games), and its developers have long maintained that if the community wants 3DFX/Glide virtualization, it's up to them to open-source it. Some members of that community have done exactly that (VirtualBox refers to this as Guest Addition content), but it's not a simple task to install it, particularly when working in older operating systems. Having installed your OS via disc or image, restart in safe mode with networking, navigate to the Guest Additions file on VirtualBox's site, then unzip and install it. Sounds simple, but if you're on Win 95, there are many compatibility hurdles to overcome when using an unzipper program or downloading the file. Even when successfully installed, 3D acceleration can be prone to crashing in VirtualBox, and has major performance issues that will impact your enjoyment of the game. If you had your heart set on experiencing old games through a trusty old OS, though, there is another way.

PARTITION LIKE IT'S 1999

Yep—partitioning your storage drive and installing an older operating system on to it might do the trick. This is overkill for the vast majority of troublesome retro games, because it's a complicated task that risks data loss if performed incorrectly. But if you really want those old Win 98 themes and your favorite games, create a partition on your chosen disk, and mark it as active by navigating to the "Boot" tab in Windows System Configuration, highlighting the desired partition, and selecting "Set as default." Then reboot and use an old OS disk to install it to the partition; http://thpc.info has a clear step-by-step guide on how to do this. Beware, though: Windows 98 and older won't have a clue what to make of your modern hardware. You will have countless driver issues and ACPI conflicts. You will have to spend hours getting it to recognize your graphics card. But for some, the satisfaction of achieving a resolution beyond 640x480 when those issues are resolved is reward in itself.

Summoning the gaming greats of yore can be a knotty problem, then, and there are many ways to untangle those knots. If the game in question falls under the DOS era, DOSBox should be the first port of call; if it doesn't, try searching for patches and fan fixes. Next, try compatibility mode. And if all else fails, well, your parents might still have that hearing-aid-beige Packard Bell tower in the attic.

Tekken 2: **Best on the console it was intended for, however possible it may be to run on PC.**

CONSOLE YOURSELF (ACTUALLY, DON'T)

Creating an artificial software environment in which a program's tricked into running successfully is one way to describe the resurrection of old PC games. It's also one way to describe console emulation on PC, which has a history as long as it is illegal.

Its origins date back to 1990, when programs such as Family Computer Emulator v0.35 allowed a handful of NES games to run on PC. Since then, almost every console has been emulated on PC, and even Nintendo's DS, with its unique control options, joined the ranks. As technical accomplishments, they're impressive, and there's a subversive thrill in seeing another platform holder's ident appearing on a PC monitor. The key difference between using old PC games on a new PC and using old console games on a new PC is that you're breaking two sets of copyright laws when you do the latter. Consoles are closed platforms, and their games are licensed strictly for use on that very specific hardware. What constitutes a PC is open to interpretation, when you factor in the Raspberry Pi, Steam OS machines, office workstations, and quad-SLI gaming rigs. What constitutes a PlayStation 4 is not. There haven't been many legal cases, but when Sony tried to sue two PS1 emulators in the 1990s, an uneasy accord was established: As an emulator doesn't re-use code, it's not illegal. The games, however, are.

The legality gets trickier when considering discontinued platforms. Arguably, since the Sega Saturn was discontinued long ago, it can be considered abandonware (along with its software library). But what if the platform comes back to life, as with Nintendo's SNES Mini? Steer clear, and concentrate on PC gaming's voluminous library instead.

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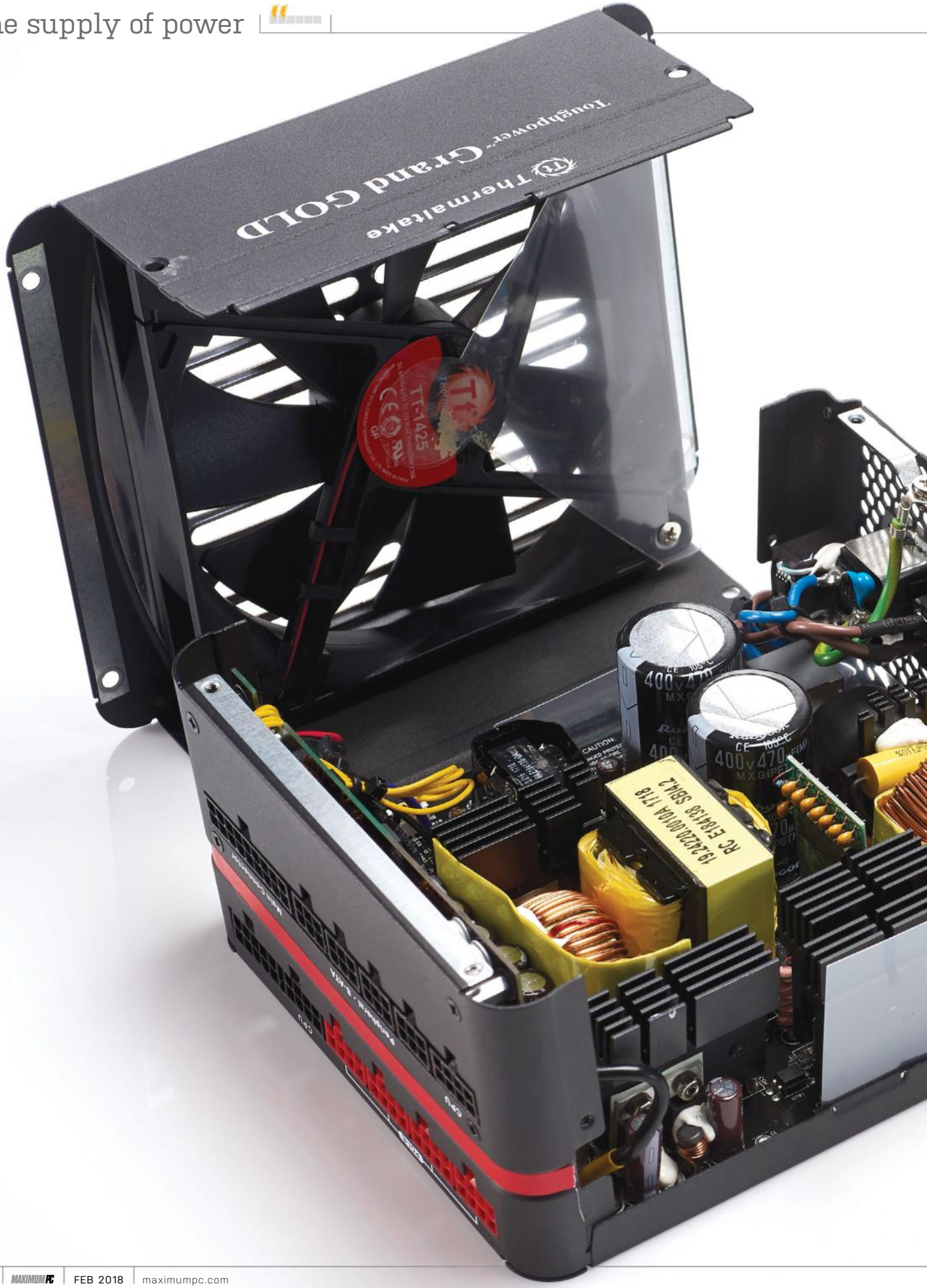
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Toughpower Grand GOLD
TT-1425
CAUTION:
400v 470
MXG

THE SUPPLY OF POWER

Everything you need to know about your PSU, and some things you probably didn't

YOUR RIG DRAWS every watt and volt it uses from one power supply unit (probably). All being well, it will sit quietly in a corner of your case and keep the magic happening. There are only three reasons to buy a new one: your existing one has gone bang or started to smell funny; you are about to embark on serious upgrading; or you're building a new rig from scratch.

Its job may be vital, but the PSU is often left until last on a component list, using the remaining budget after you've picked out the good stuff. A power supply is a power supply—as long as it's big enough, you just plug it in, and it works, right?

There's a bit more to it than that. A good one lasts a long time, stays cool, and enables future expansion and stable overclocking. Get it wrong, and you'll be back ordering another, and possibly other components, too, because when a PSU goes bang, it can take other parts along with it.

The current standard for PSUs is ATX, which surfaced in 1996, replacing the ancient AT. The latest iteration is ATX 2.31, dating from 2008, which shows how leisurely the development of PSU standards is. That's not to say PSUs aren't evolving; the huge appetite for power of the graphics sub-system, and the world of overclocking, has put great demands on the PSU. The latest ones are adding digital control circuits; you can even get ones with Bluetooth, so you can run them from a phone app. So, how many watts do you really need? And why do prices vary so much?

The 6+2 PCIe 12V power connectors. These feed the appetites of GPUs. If your PSU has two of these, and two six-pin versions, it was designed to run two graphics cards.

With modular cabling, you only install the cable you need. Better PSUs are fully modular, mid-range ones are often partly so; both reduce the colored spaghetti look.

THE ELECTRICITY FROM your wall outlet is completely wrong for your PC. It delivers a 120V 60Hz alternating current (technically it is 120V +/-5 percent; the median value is actually 117V). This is great for chunky electric motors or making toast, but inimical for the delicate circuit boards inside your PC—nothing can use this unmodified, it's way too powerful, and everything wants a direct current instead. The PSU's one and only job is to transform this supply into tech-friendly low-voltage DC varieties. The original IBM PC's power supply delivered 63.5W—things are a little more taxing now.

A PSU is an SMPS—a switched mode power supply. It switches from full power to none and back quickly. The voltage is regulated by adjusting the switching ratio between full-on and off. The idea has been around since the 1830s, but it took modern transistors to put them into everyday consumer electronics. An SMPS is smaller, lighter, and more efficient than plain old linear designs, which waste excess power as heat. Old-timers may remember when transformers were heavy bricks; no longer. The main drawback is that the switching introduces high-amplitude, high-frequency interference, which needs to be filtered out.

There are eight main stages in a switched power supply. These are: input filtering, primary bridge rectifier, primary capacitors, primary switching transistors, transformers, secondary rectifiers, output filtering, and finally feedback and protection circuits. The bridge rectifier is an arrangement of four diodes that only allows electricity to pass one way, thus the sine wave of an AC current is turned into a saw-toothed DC one. This is then switched on and off very quickly, and fed into the main transformers to be stepped down to the required voltage. And, yes, we have skirted around some of these stages, because, quite frankly, you don't need to know, and it may involve diagrams.

What every component in a PC really wants is a steady voltage, but all the business of transforming and rectifying adds noise to the signal. Enter the capacitors. These are passive devices used in PSUs to smooth out the ruffles in a current. They are rapidly charged and discharged, but as they resist rapid changes in voltage, the peaks and lows of the signal are never reached. This turns a jagged signal into a much smoother one. You'll find them both on the primary side of the PSU, dealing with the incoming AC current, and on the secondary side, smoothing the DC current from the rectifier.

The Japanese have something of a reputation here. Years of extremely high production standards, purity of materials, and quality control have given them an enviable reputation. Many spec sheets proudly boast of Japanese 105 C rated electrolytic capacitors, the ones to look for. Good capacitors are expensive, and this is one area where budget PSUs cut corners.

A PC requires its juice in three strengths: 12V, 5V, and 3.3V. The main 12V is used for the processor and PCIe cards, as well as fans, drive motors, and anything else that needs a decent amount of power. The 5V supply is used for drive controllers, parts of the motherboard chipset, including the BIOS and CMOS, and other sub-systems—USB, PCIe control circuitry, and such. The 3.3V rail typically runs your RAM, some graphics card functions, and other control circuitry. The majority of the power requirement of your PC falls on the 12V supply, and it's this that needs the most attention.

The motherboard also has a number of VRMs—voltage regulation modules—to supply the more delicate components. The processor has its own 12V supply, for example, but you couldn't send that through any processor made since the 1970s. VRMs use switching transistors to lower a DC current. They are multiphase synchronous buck converters. Note the term "multiphase." Each phase means adding a set of transistors, which increases the stability of the output, reducing ripple (we'll get to that). More phases doesn't mean more power—that depends on the amperage rating of the transistors. More is definitely better, though.

RAIL REALITIES

To supply the main voltages, the PSU has a number of rails. A rail is a separate line of connections, which has a set monitored and limited output, to avoid excessive heating and dangerous loads. There are 12V, 5V, and 3.3V rails, plus a small 5V standby rail, and a now virtually unused -12V rail kept for compatibility. 2003's ATX 2.0 spec calls for two 12V rails: one for the processor, and one for everything else. Originally, these were rated at 20A each. This is equivalent to 240W (watts = amps x volts).

Generally, a single 12V source was split into two rails, with the lower voltage rails

"A PC wants a steady voltage, but transforming and rectifying adds noise to the signal."

The $450 EVGA SuperNOVA: 1,600W of power—far too much, of course. Unless you really do want four graphics cards.

Corsair's flagship AXi PSUs were the first to use digital control circuits, enabling you to remotely monitor and control them.

CoolerMaster makes much of its fans, as you might expect. This compact V650 comes in at about $180. Poky enough for a very demanding single graphics card box.

running off the 12V supply, using VRMs to drop the voltage. Building fully independent rails is expensive. A few specialist PSUs boast "real" multiple rails—however, almost all actually run one and split the output. The high demands of graphics cards, all of which fell on a single rail, soon caused problems, and the power demands hit the buffers of the ATX specifications. PSUs started to split out more rails to cope. These were configured (or should have been; there were some early failures) to spread the power-hungry PCIe loads. Each rail's power rating is its limit before circuit protectors cut in. It does not mean the PSU can supply that level of power across all the rails; there's still a maximum 12V it can deliver, which may be lower. In 2007, ATX 2.3 finally dropped the 20A limit, one which was increasingly being breached.

Enter the one big 12V rail design. Gamers have traditionally liked these—you don't have to worry about spreading loads. Just connect everything, and let the hardware draw what it needs from a common pool. Job done. Splitting down is inherently safer, though—if a part fails on a single rail PSU, it can potentially get a huge amount of power sent through it, a hefty shock, and possibly a fire. The single rail design is in favor these days, especially for enthusiast rigs, although the server room boys still like their safer multiple rail designs. Some PSUs offer both, with the ability to be configured as one big rail, or multiple lower amperage ones. A neat solution.

And now back to those ripples. These are tiny, rapid fluctuations in the voltage. They are a consequence of the AC to DC conversion, a harmonic distortion at the switching frequency, and are expressed as a deviation in mV (millivolts). The ATX specifications lay down allowable levels: 120mV on the 12V supply, and 50mV on the others. Excessive ripple can cause damage to hardware. Fortunately, not the burning and smoking kind, but it does stress electrolytic capacitors in particular, lowering their lifetimes.

Good ripple suppression means better overclocking potential. Faster clock speeds mean less time for the VRM to reach the required voltage; a ripple at the wrong moment of a clock cycle can mean it never reaches the required operating voltage, and it becomes "unstable." If you are intent on some serious overclocking, look for a PSU with good ripple suppression on the 12V rail. A lot of progress has been made here recently, and high-end PSUs can manage down to 30mV; the very best boast 10mV.

FAILURE FACTS

Decent PSUs are reliable, but like everything, they don't last for ever. The main reason for PSU failure is the fan. If this goes, your PSU rapidly overheats under load. A good PSU has a good fan—it should be as good as or better than your processor cooler and case fans. There's no point in a PSU with a life of 100,000 hours being cooled by a sleeve-bearing fan with a life of 50,000. Single-fan PSUs always have an exhaust fan, sucking air from inside the case, across the PSU's heatsinks, and out the case. Look for designs that can run without a fan at low loads, known as Eco mode. Some don't need the fan until loads hit 40 percent—well above idle.

Capacitors have a limited lifespan, too, which is affected by how hot they get. They can leak, which gets nasty. At this point,

Of course, there are LEDs. Thermaltake's $120 850W Toughpower Grand boasts a 14 RGB LED fan—plus some decent specs.

A basic $30 PSU, here from EVGA. This still delivers 400W in total, with 360W through a single 30A 12V rail.

WHEN IS 200W ACTUALLY 250W?

A 500W PSU uses 500W of power at full load, right? Nope, the work the PSU does in transforming, rectifying, and smoothing has its cost, in heat principally. This efficiency is expressed as a percentage. If your rig draws 200W, a typical 80 percent efficiency PSU draws 250W from the wall to do it. The efficiency is not constant—running flat out or at very low levels is more inefficient. The sweet spot is at a load of 40–60 percent. A good quality PSU tends to have a flatter efficiency curve.

In the early days, efficiencies were low; ATX 2.01 only required 60 percent at a 20 percent load. To improve things, the 80 Plus program was launched by the American Council for an Energy-Efficient Economy in 2004. To earn the logo, a PSU must be a minimum of 80 percent efficient at loads of 20 percent, 50 percent, and 100 percent. Further standards followed: 80 Plus Bronze takes us to 85 percent efficiency at 50 percent loads, and 82 percent at 20 and 100 percent loads. Silver added 3 percent and Gold another 2 percent. As we approach 100 percent, it is harder to engineer. In 2009, the first Platinum PSU appeared, pushing efficiencies to 90, 92, and 89 percent. The highest current rating is Titanium—it appeared in 2012, and manages 92, 94, and 90 percent.

Efficiency costs. You need more and better quality components. Electricity costs, too. If your rig is on for long periods, some calculations may be required to pick the most cost-effective PSU. A 500W Gold PSU over a Bronze may cost an extra $50, but only earns an extra 5 percent in efficiency, which may take years to get back in savings. However, high efficiency also gives a good indication of build quality.

HOW MANY WATTS DO YOU NEED?

It's usually not as many as you think. A decent single graphics card gaming rig is happy with 500–600W. Put very roughly, a nicely specced modern rig with multiple drives needs 200–250W at most, plus the CPU and graphics card.

We did consider offering a quick list of what uses what—a 10TB hard drive, for example, needs 7–10W—but the list would be too long, and there are online calculators that can do this for you. OuterVision has a good one that includes processor and GPU overclocking, plus it shows potential savings obtained by using higher efficiency ratings.

Plan ahead. Are you ever going to fit two graphics cards, or overclock? Specify for the most extreme your rig is ever going to get—you do not want to buy twice. Given the graphics system is where the pressure is, look for recommendations from graphics card manufacturers. For example, an Nvidia GTX 1080 Ti or GTX Titan asks for 600W, and 850W if you double up. Drop to a GTX 1060, and 450W will cover things.

AMD cards are more demanding—the Vega 64 is notoriously power-hungry. A single Vega 64 wants 600W, but a dual rig asks for 1,100W. The most extreme recommendations include a dual Vega 64 Liquid Edition or quad GTX Titan; these want 1,350W. A four-card Radeon R9 Fury X tops this at 1,600W. Yowsers.

If you plan to overclock, another 50–100W should cover things, but you need a good clean current, so go high quality. There is no ideal value. It just needs to be enough to run everything without stressing the PSU—an extra 100W over won't hurt; much more means paying for something you'll never use.

you may get some capacitor squeal—this is gas venting through a pinhole in the casing, making a whistle. If you can hear this, failure is imminent. Less worrying, and more likely as a source of an annoying sound, is coil whine. This is when induction coils start to vibrate under load; this varies in pitch and intensity with the current. If these coils are inside your PSU, there is not a lot you can do. They may "bed in" after a while; they may not. A good PSU will have tested and damped its coils properly.

It may be tempting to use an old ATX power supply you happen to have hanging around, doing nothing, in a new system—not recommended. It may technically fall within ATX specifications, but these are pretty loose, and a lot has changed in the last few years, particularly the distribution of power requirements, which has moved off the 5V and 3.3V rails and on to the 12V one. A perfectly good, but old, ATX supply makes a poor partner for modern rigs. If it still has a 20A 12V rail, for example, you'll struggle if you load the PCIe system.

Power is delivered to your system through a set of cables with standardized connectors for each job. The wires are color-coded (or used to be; it appears to be going out of fashion): The +12V power line is yellow, the +5V is red, and the +3.3V is orange. Time was a PSU came with a mess of cables dangling from it, each hardwired with a connector. This is unruly, because any connectors you don't require are left dangling about inside, and you may have to start using adapters and splitters to get everything powered.

MODULAR MERITS

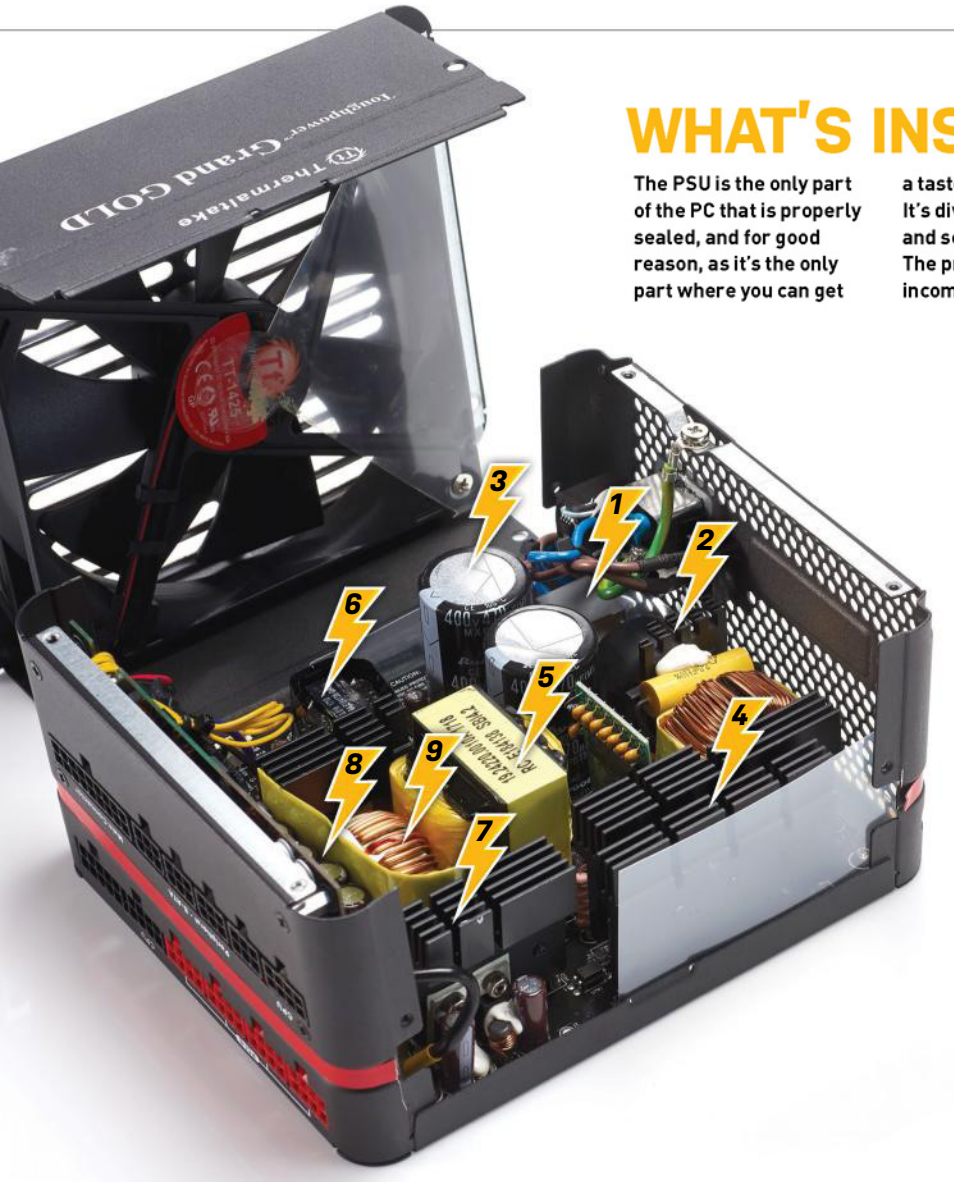
Better PSUs now have either a partly or completely modular cable system. The PSU has blocks of sockets, and it comes with a set of separate cables, often snazzy rounded, flattened, or braided ones. You only need to install the cables you need. This looks good, improves airflow and is much neater.

PSUs only draw the power they are asked for, so over-specifying won't cost you, other than the initial outlay. The chances of you putting too much strain on the 5V and 3.3V rails is next to none. These components simply don't draw much power, and any decent PSU allows more than enough. It's the 12V side you need to match with your hardware. So, where is the 12V power going? There are two devices that soak this up, and the culprits are the processor and the graphics card. Compared to these, everything else is a lightweight.

Processors have a TDP figure, expressed in watts. This is the thermal design power, and is the maximum heat a processor generates under a heavy load. It can be exceeded in certain conditions, and isn't the same as electrical power consumption—

"If your budget has scope, go for a better quality PSU in preference to a bigger one."

Some nice Japanese electrolytic capacitors help to smooth out the current.



WHAT'S INSIDE THE BOX?

The PSU is the only part of the PC that is properly sealed, and for good reason, as it's the only part where you can get a taste of mains power. It's divided into primary and secondary areas. The primary deals with incoming power, and feeds it into the switcher. The secondary deals with the final output of DC currents. Between them is the main transformer.

1 INPUT FILTERING
Switching introduces considerable interference, which you don't want getting out into the mains supply.

2 BRIDGE RECTIFIER
An arrangement of four diodes that converts the AC current into a DC one, although a rather ragged one.

3 PRIMARY CAPACITORS
These smooth out the saw-toothed unregulated signal from the rectifier. The better quality these are, the smoother and more reliable the signal.

4 SWITCHING TRANSISTORS
This switches power on and off at very high frequencies—about 25kHz. By adjusting the relative proportions, you can modify the output levels, so the PSU can deliver only the level of power required.

5 MAIN TRANSFORMER
Two induction coils on a ceramic ferrite core. These step down the input into usable voltages. It also isolates the mains power from your PC's insides. Its main job is making a 12V supply; there may be a "tap" for 5V, too.

6 +5VSB TRANSFORMER
This provides the standby power. It is always active, even when the PSU is "off."

7 SWITCHING REGULATORS
More transistors and diodes working as switching regulators on the DC current, rectifying and filtering the current.

8 SECONDARY CAPACITORS
Also used to smooth out signals, this time on the regulated DC current, ready to go outside the box to the case.

9 TOROIDAL COILS
An inductor made by wrapping wires around a donut-shaped ferrite core. The magnetic field generated by the current through the wire induces a current in opposition. This resistance helps smooth out interference. There is quite a bit of this inside a PSU, and hence several of these in various sizes.

however, it is a pretty good indication of what you will need. For example, a Ryzen 1700X has a TDP of 95W. Under very heavy test loads, it actually needs feeding about 105W. An i7-6900K has a high TDP of 140W, and needs about 148W at its absolute worst. These figures are enough to run the rest of the system put together. The most extreme desktop chip is AMD's Threadripper, which has a TDP of 180W.

The processor isn't the big one, though—that's the graphic card. The technology has really bloomed over the last few years, but so has power consumption. Originally, the PCIe slot was enough; it carries 75W, taken from the motherboard's 12V feed. This was soon supplemented by a six-pin PCIe power connector, which added more 12V power lines direct from the PSU, and 75W. A second six or eight-pin connector added up to another 75 or 150W, bringing our total to a potential draw from one graphics card to 300W. This pretty much matches the rest of the system, including processor, added together. Some cards are going beyond the PCIe 3.0 specifications by using two eight-pin PCIe connectors, for a maximum of 375W. PCIe 4.0 is expected to standardize this, or something similar, shortly.

The novice mistake is to spend your budget on a big wattage supply that you don't really need. One matched to your components, with a moderate amount of breathing room, is enough. If your budget has scope, go for a better quality PSU in preference to a bigger one. Look for better ripple suppression, high-quality capacitors, fan and energy efficiency, sophisticated circuit protection, and such, rather than just getting the biggest headline number of watts. It's about supplying the power reliably, efficiently, and smoothly for the whole life of your rig. Get it right, and you won't be buying another for some time.

TECH POR

PERFORMANCE GE

Aorus X9 Laptop

LET'S BE HONEST, this laptop is a lot of dollar. No, seriously: 3,650 of the smackers straight from your wallet and into a not-so-portable 17-inch, RGB-lit, behemoth of death. That aside, there's good reason for the high price tag, and Gigabyte's Aorus has certainly garnered a reputation recently for being quite the premium brand around the gaming sphere. Aorus is to Gigabyte as Shelby is to Ford. Well, maybe that's being a touch too generous, but you get the gist. The X9 is currently one of the world's better specced slimline-yet-powerful gaming laptops, featuring dual GTX 1070s in SLI, a quad-core Intel Core i7-7820HK CPU, 32GB of DDR4, and a whole bank of PCIe solid-state storage to boot. But the big sellers reside with the screen and the keyboard (see below). Available with either an IPS 4K panel or a 1440p 120Hz VA panel, it's entirely your choice as to whether you want a faster refresh rate or crisper visuals. –ZAK STOREY

1 Mech Heaven

The beauty of the X9's design stems from its mechanical keyboard. With slim manufactured switches, these genuinely feel like the real deal. Impressively, Gigabyte has incorporated this without shifting the hardware around, or affecting the overall size of the device.

2 Screen Mastery

It's up to you what screen you play with on the X9. You can either go for a more color-accurate IPS 4K 60Hz affair, or, if you like your games buttery smooth and vibrant, a 1440p 120Hz VA panel is available instead. However, there's no sign of any form of sync here.

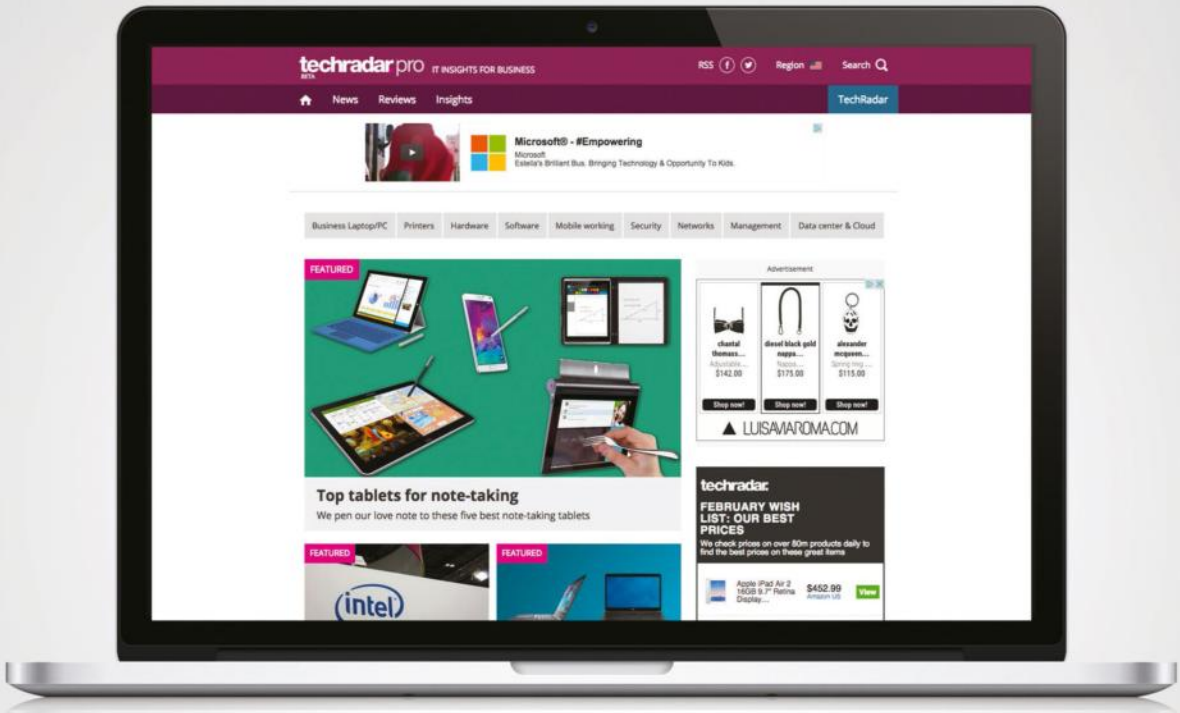
3 Subtle Lights

OK, so you can tell this is a gaming laptop. Whether it's the hawk head on the trackpad, the sports car style air vents, or the angular design of the body, there's little about this that says sophisticated. That said, the included RGB lighting is actually quite subtle. And we've gotta say, we like it.

Future

techradar.pro

IT INSIGHTS FOR BUSINESS



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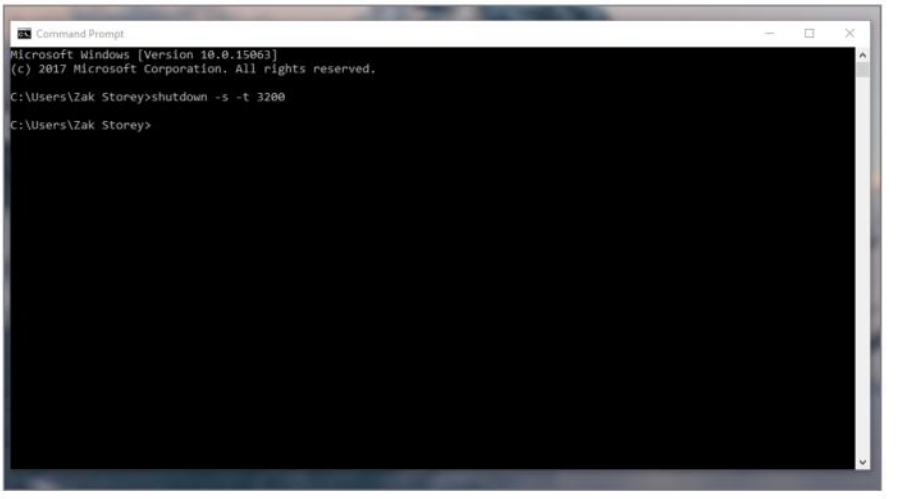
In-depth reviews

http://www.techradar.com/pro

HOW TO

STEP-BY-STEP GUIDES TO IMPROVING YOUR PC

TIP OF THE MONTH


Command Prompt
Microsoft Windows [Version 10.0.15063]
(c) 2017 Microsoft Corporation. All rights reserved.
C:\Users\Zak Storey>shutdown -s -t 3200
C:\Users\Zak Storey>

SHUTDOWN TIMERS

Ever needed to run your rig for a specific length of time? If, like us, your download ETAs run late into the night, sometimes it's easier to run a shutdown timer to get the job done. There's a ton of free programs that do this, but we find good old command prompt does the job best. Open a command prompt, and type "shutdown -s -t XXXX" where the Xs are the time in seconds that you want your system to wait before shutting down.

ZAK STOREY
DEPUTY EDITOR

A NEW DESK

I love custom desks. I'm not talking about crazy liquid-cooled gargantuan super-desks, but something a little more standard, yet still unique to me. My current setup is a cheap and simple reclaimed wood affair. Basically, I grabbed a ton of free pallets from my local wood recycling center, stripped and sanded them down, slapped them across five feet of 2x4, distressed them a little, painted them white at the request of the wife-to-be, and then sat them on top of two Ikea trestle legs, with a reinforced glass top. It looks lovely, but a little haphazard. Different pallets meant different-height planks on top, and although the glass alleviates the effect somewhat, it's starting to niggle at me, especially after a year and a half of use. So, then: new year, new desk, new build.... And screens. Oh god!

The biggest expense with the old desk was the glass top; this time, I'm going to invest my money in better quality wood, legs, and a few creature comforts instead, in an effort to make something that feels far more premium than the last one.

I'd love to include one of Ikea's integrated wireless chargers, and get some smart cable management in as well. Warm LED backlighting is a must, and with my plans to invest in two 32-inch 4K screens from the likes of ViewSonic, a dual monitor arm is needed too. There's a lot to it. I'm no carpenter, but I'm quite positive this shouldn't be too difficult to pull off....

MAKE – USE – CREATE

56
Make a secret kill switch for your Pi in case of attack

62
Create artistic blur in Photoshop and bring images to life

66
Discover how we invigorated a decrepit editorial PC

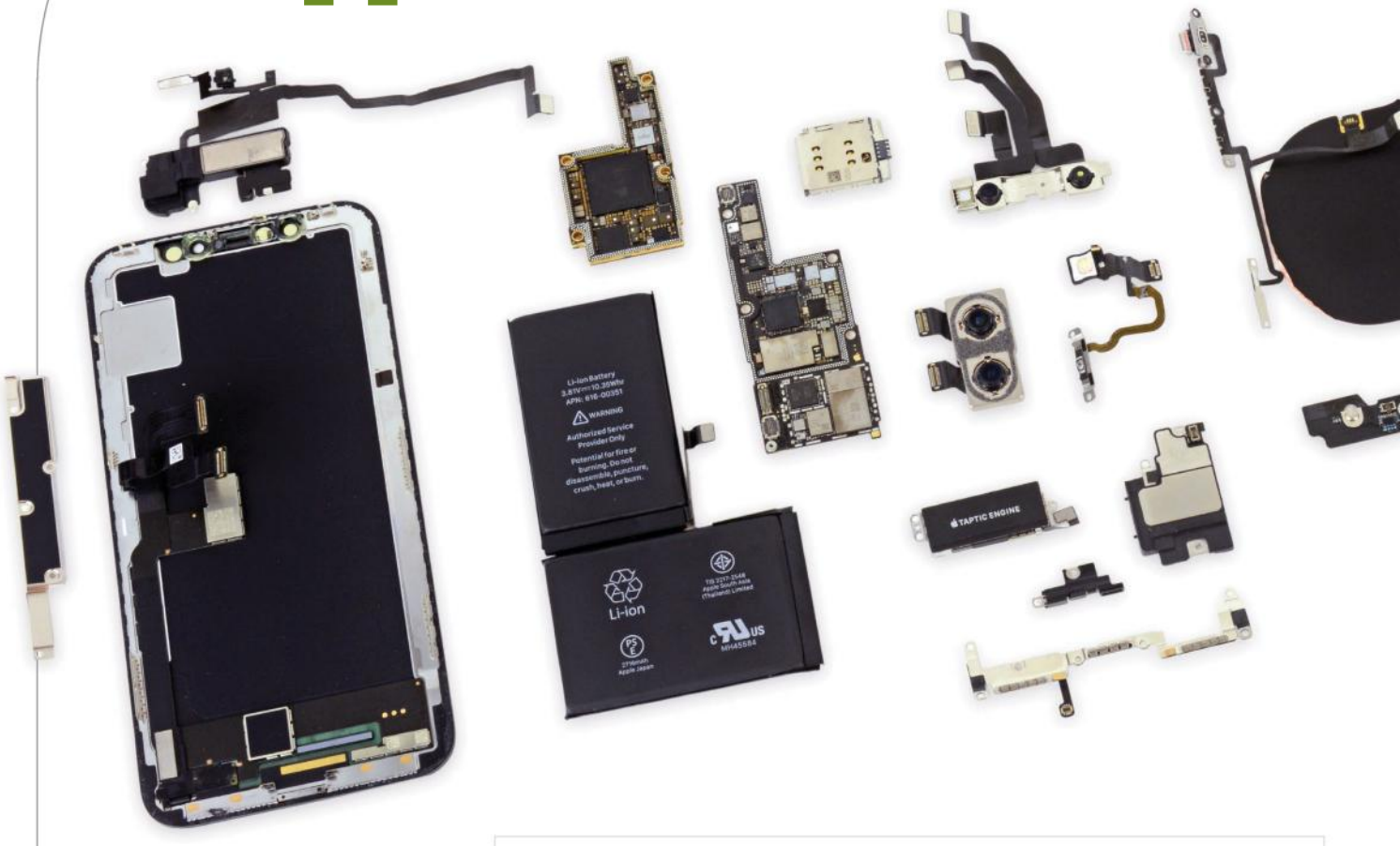
↘ submit your How To project idea to: comments@maximumpc.com

IFIXIT presents:

AUTOPSY

THIS MONTH WE DISSECT...

Apple iPhone X



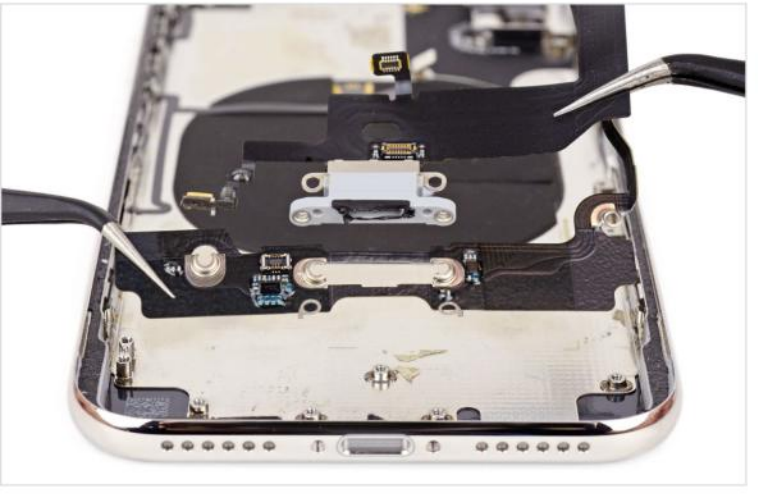
Once you're properly inside, there's not much to see beyond a whole lot of battery.

About iFixit

iFixit is a global community of tinkerers dedicated to helping people fix things through free online repair manuals and teardowns. iFixit believes that everyone has the right to maintain and repair their own products. To learn more, visit www.ifixit.com.

The iPhone X has arrived! Here's the fillin' inside that glass sandwich.

Time to show off some double tweezer action while removing the lightning connector.



BACKGROUND

Ten years ago, Apple introduced the first iPhone. Now we're taking apart the 18th iteration—the iPhone X. With its rounded edges and edge-to-edge display, we're sure this is the iPhone Steve imagined all those years ago—but now that his dream is realized, will it be as influential as the first? Time will tell....

MAJOR TECH SPECS

- A11 "Bionic" chip with neural engine and embedded M11 motion coprocessor
- 5.8-inch OLED multitouch 2436x1125 (458 ppi) Super Retina HD display
- Dual 12MP cameras (wide-angle and telephoto), with f/1.8 and f/2.4 apertures, and OIS
- 7MP TrueDepth camera with f/2.2 aperture, 1080p HD video recording, and Face ID
- Support for fast-charge and Qi wireless charging
- Our A1865 global unit has broad cellular band support as well as 802.11a/b/g/n/ac Wi-Fi, MIMO, Bluetooth 5.0, and NFC

KEY FINDINGS

- The iPhone has come a long way in 10 years—so long, that the design has cycled back a bit, and this looks more like the original than we've seen in a long time. As with the iPhone 8, Apple has banished the unsightly (and environmentally responsible) regulatory markings from the back.
- The pentalobe screws at the bottom look weirdly unfinished—the bottom ones are more like pins. Luckily, they haven't rearranged too much else, as our typical trifecta of iOpener, iSclack, and iFixit Opening Picks works, as in the past.
- Looks like sideways-opening iPhones are here to stay. Inside, a single bracket covers every logic board connector—we've never seen this kind of connector density. We're faced with tri-point screws standing sentry over any repairs once you get past the pentalobe screws guarding the door. Something tells us Apple doesn't really want us tinkering.
- We finally free this most dense of logic boards to get a closer look—it is incredibly space efficient. Comparing the two boards, the iPhone X motherboard is about 70 percent of the size of the iPhone 8 Plus board—more space for battery.
- The dual rear camera has a beefy bracket that looks like it might offer some bendgate-proofing support for the delicate components. The cameras are also secured to the rear case with some foam adhesive to keep things from jostling out of place. These cameras really need to stay put for Portrait Mode and similar features to work their magic. Surrounding the camera housing cover glass, you can see tiny spot welds, likely holding the walls of the camera bump to the case.
- Repairability Score: 6 out of 10 (10 is easiest to repair). Display and battery repairs remain a priority. A cracked display can be replaced without removing the biometric Face ID hardware. Liberal use of screws is preferable to glue—but you'll need Apple-specific drivers (Pentalobe and tri-point), in addition to a standard Phillips. Waterproofing complicates some repairs, but makes difficult water damage repairs less likely. Fussy cables tie unrelated components into complex assemblies—expensive and troublesome to replace. Glass on front and back doubles the likelihood of drop damage—and if the back glass breaks, you'll be removing every component, and replacing the entire chassis.

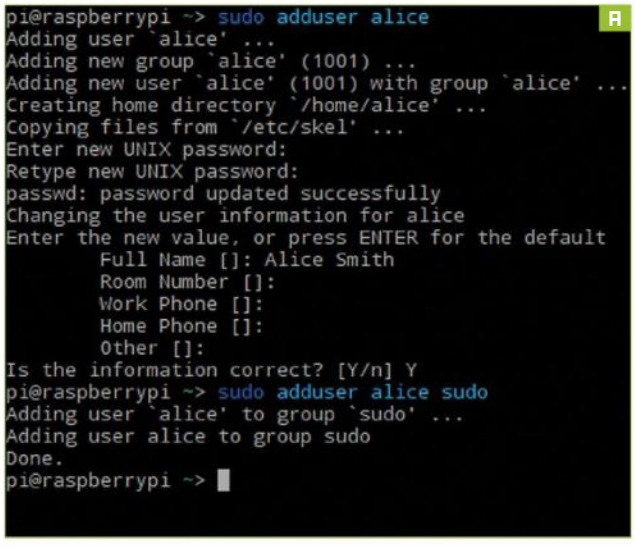
Make a Secret Kill Switch for Your Pi

YOU'LL NEED THIS

RASPBERRY PI
Any model is suitable.

IF YOU'RE WORRIED about the somewhat Orwellian notion of a forced disclosure of passwords, this coding project posits a rather radical solution to the dilemma: Create a second password for your user account, which, instead of logging you in, nukes your home folder using special tools.

As extreme as this sounds, it's surprisingly simple to set up. A couple of disclaimers: Make sure you back up your personal data to a safe place before going ahead with this project. Also, bear in mind that it's not an infallible method, because anyone with physical access to your machine may seize it before you have a chance to flip this kill switch. –**NATE DRAKE**


A
pi@raspberrypi ~> sudo adduser alice
Adding user `alice' ...
Adding new group `alice' (1001) ...
Adding new user `alice' (1001) with group `alice' ...
Creating home directory `/home/alice' ...
Copying files from `/etc/skel' ...
Enter new UNIX password:
Retype new UNIX password:
passwd: password updated successfully
Changing the user information for alice
Enter the new value, or press ENTER for the default
Full Name []: Alice Smith
Room Number []:
Work Phone []:
Home Phone []:
Other []:
Is the information correct? [Y/n] Y
pi@raspberrypi ~> sudo adduser alice sudo
Adding user `alice' to group `sudo' ...
Adding user alice to group sudo
Done.
pi@raspberrypi ~>

1 CREATE YOUR NEW USER ACCOUNT

Although you probably already have a user account on your Raspberry Pi, create a new one for this project by opening Terminal on your Pi, or connecting via SSH, and running:

```
sudo adduser name
```

›› Add your new user as an Administrator with:

```
sudo adduser name sudo
```

›› Substitute "name" with your chosen username [**Image A**].

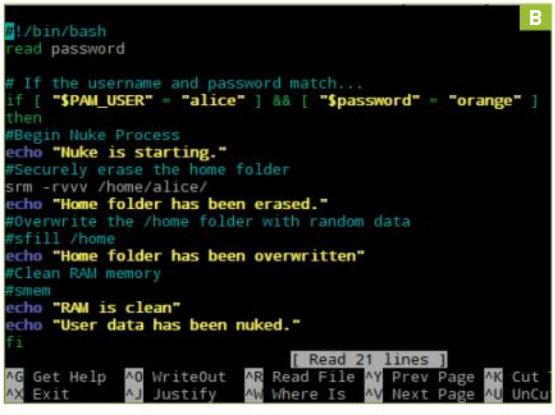
2 CREATE YOUR NUKE SCRIPT

You should stay logged into the "Pi" user for now, and run the following command:

```
sudo nano /etc/security/security.sh
```

›› In the new window, enter the following [**Image B**]:

```
#!/bin/bash
read password

# If the username and password match...
 if [ "$PAM_USER" = "name" ] && [ "$password" =
"nukepassword" ]
then
#Begin Nuke Process
echo "Nuke is starting."
#Securely erase the home folder
srm -rvvv /home/name/
echo "Home folder has been erased."
```


B
#!/bin/bash
read password
If the username and password match...
if ["$PAM_USER" = "alice"] && ["$password" = "orange"]
then
#Begin Nuke Process
echo "Nuke is starting."
#Securely erase the home folder
srm -rvvv /home/alice/
echo "Home folder has been erased."
#Overwrite the /home folder with random data
#sfill /home
echo "Home folder has been overwritten"
#Clean RAM memory
#smem
echo "RAM is clean"
echo "User data has been nuked."
fi
[Read 21 lines]
^G Get Help ^O WriteOut ^R Read File ^Y Prev Page ^K Cut
^X Exit ^J Justify ^W Where Is ^V Next Page ^U UnCu

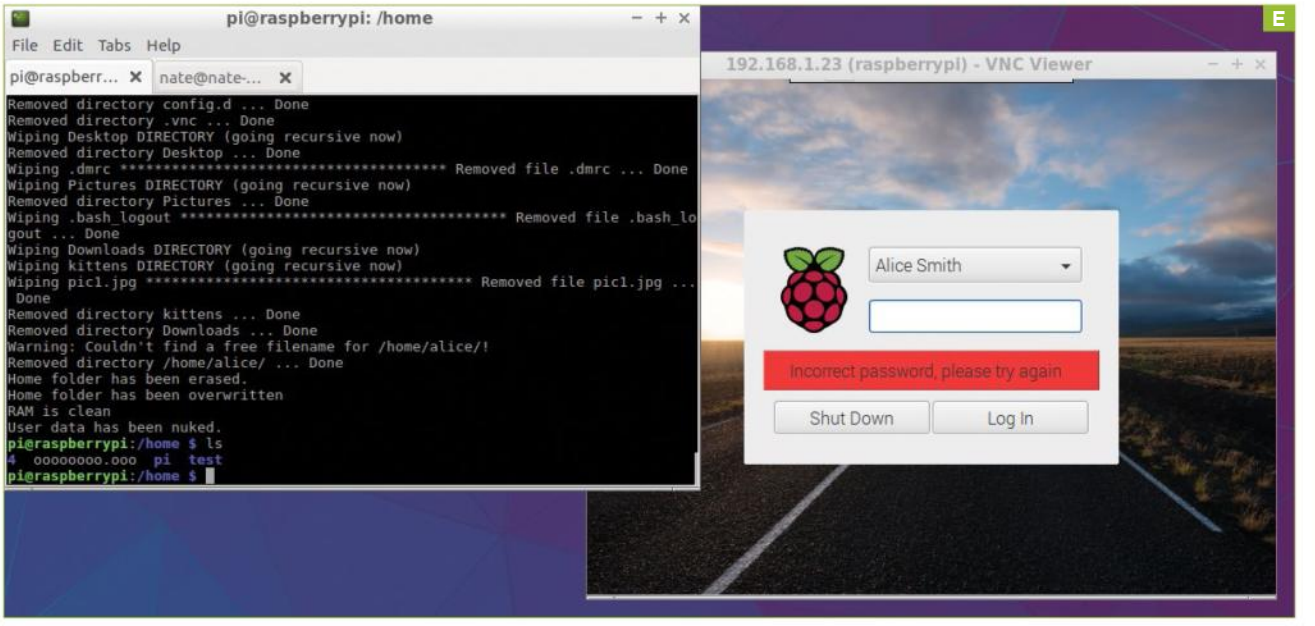
```
#Overwrite the /home folder with random data
#sfill /home
echo "Home folder has been overwritten"
#Clean RAM memory
#smem
echo "RAM is clean"
echo "User data has been nuked."
fi

exit 0
```

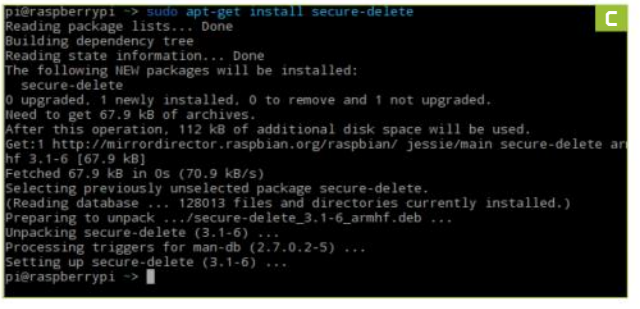
3 MODIFY THE SCRIPT

In the code, you need to substitute "name" and "nukepassword" for the username of your new account and the desired nuke password. Make sure this is different from your current one. You also need to change the line "srm -rvvv /home/name/" to reflect the path of your real home folder.

HIDDEN EXTRAS

In addition to the "srm" command in the nuke script, which securely erases the home folder, you may have noticed that there are two other commands: "sfill" and "smem." Remove the # at the start of these lines to overwrite the free space in the /home folder, and clean any files in the Pi's virtual memory (RAM) respectively. This takes much longer than the "srm" command on its own, but is a good deal safer.


pi@raspberrypi: /home
File Edit Tabs Help
pi@raspberr... nate@nate-...
Removed directory config.d ... Done
Removed directory .vnc ... Done
Wiping Desktop DIRECTORY (going recursive now)
Removed directory Desktop ... Done
Wiping .dmrc ********** Removed file .dmrc ... Done
Wiping Pictures DIRECTORY (going recursive now)
Removed directory Pictures ... Done
Wiping .bash_logout ********** Removed file .bash_logout ... Done
Wiping Downloads DIRECTORY (going recursive now)
Wiping kittens DIRECTORY (going recursive now)
Wiping pic1.jpg ********** Removed file pic1.jpg ... Done
Removed directory kittens ... Done
Removed directory Downloads ... Done
Warning: Couldn't find a free filename for /home/alice/!
Removed directory /home/alice/ ... Done
Home folder has been erased.
Home folder has been overwritten
RAM is clean
User data has been nuked.
pi@raspberrypi:/home $ ls
4 ooooooo.ooo pi test
pi@raspberrypi:/home $
E
192.168.1.23 (raspberrypi) - VNC Viewer
Alice Smith
Incorrect password, please try again
Shut Down
Log In


C
pi@raspberrypi ~> sudo apt-get install secure-delete
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following NEW packages will be installed:
secure-delete
0 upgraded, 1 newly installed, 0 to remove and 1 not upgraded.
Need to get 67.9 kB of archives.
After this operation, 112 kB of additional disk space will be used.
Get:1 http://mirrordirector.raspbian.org/raspbian/ jessie/main secure-delete armhf 3.1-6 [67.9 kB]
Fetched 67.9 kB in 0s (70.9 kB/s)
Selecting previously unselected package secure-delete.
(Reading database ... 128013 files and directories currently installed.)
Preparing to unpack .../secure-delete_3.1-6_armhf.deb ...
Unpacking secure-delete (3.1-6) ...
Processing triggers for man-db (2.7.0.2-5) ...
Setting up secure-delete (3.1-6) ...
pi@raspberrypi ~>

4 RUN NUKE SCRIPT ON LOGIN

Make your nuke script executable with the command:

```
sudo chmod a+x security.sh
```

›› Next, run

```
sudo nano /etc/pam.d/common-auth
```

›› This opens the Pluggable Authentication Modules (PAM). Find the line starting "auth [success=1..." and change this to "auth [success=2..." Immediately below this line, type the following:

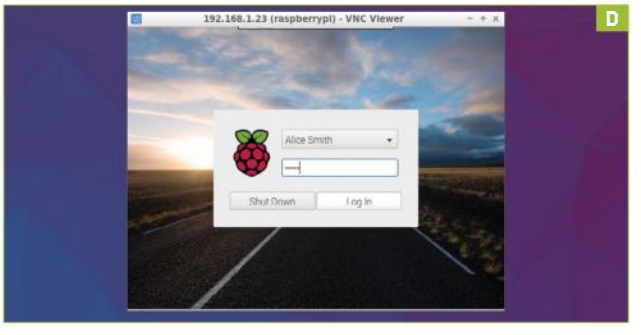
```
auth optional pam_exec.so expose_authtoklog=/tmp/pam.log /etc/security/security.sh
```

5 INSTALL SECURE DELETE TOOLS

Run the following command:

```
sudo apt-get install secure-delete
```

This installs the tools that are necessary to erase your home folder securely [Image C].



6 MIGRATE YOUR DATA (OPTIONAL)

If you previously had personal data in another user account, you should take this chance to move data across from that account to another from your backup drive. If you wish to delete the originals, do so using the new secure-delete tools, for instance:

```
srm -r /home/bob/Pictures
```

7 TEST YOUR NEW ACCOUNT

Reboot your Raspberry Pi and log into your new user account using the normal login password [Image D]. Take a moment to check that your files are where you need them.

8 TEST YOUR NUKE SWITCH

If your data is backed up, there's no harm checking that your nuke password works. Reboot the Raspberry Pi once again. Select your new username and enter the nuke password. The system will hang while it removes your files.

9 CHECK NUKE LOGS

You can still connect to the Pi via SSH while the nuke script is running. Use the following command to check the progress of the nuke:

```
cat /tmp/pam.log
```

›› Any further attempts to log in just take the user back to the login screen [Image E].

NUCLEAR DETERRENT

A nuke switch may appeal to your sense of melodrama, but it's likely that if an unscrupulous person seizes your Pi, they will make a copy of the contents of the SD card before trying to enter the password. Ideally, you should encrypt your home folder before using this script. Even if it does work, the script cannot delete itself, so it will be obvious to everyone that you have "gone nuclear."

Harden Your WordPress Security

YOU'LL NEED THIS

WORDPRESS INSTALLATION
In addition to the obvious.

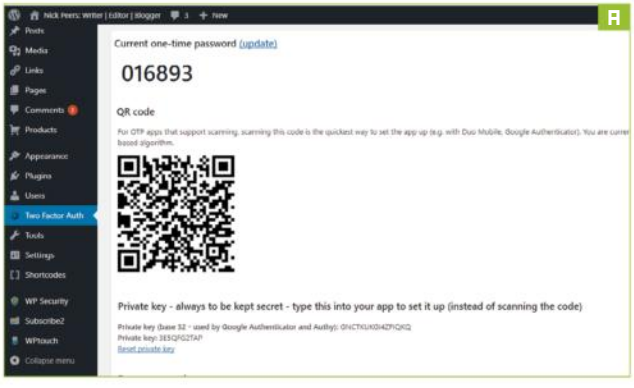
FREE PLUGINS
All referenced in the tutorial.

SSL CERTIFICATE
Required to switch to HTTPS-only connections.

A SELF-HOSTED WORDPRESS SITE—one not hosted on http://wordpress.com—is one of the easiest ways to build and maintain an independent web presence, whether it's a blog, online magazine, or even an ecommerce store. But one thing that's often overlooked with WordPress is security.

In this tutorial, we're going to perform a security audit, and enact several additional layers of protection to "harden" your WordPress installation. Not only will you be surprised to learn how vulnerable your WordPress-powered site has been up until now, but you'll also be relieved to learn that, armed with the right settings and plugins, you can close most of its loopholes.

There are plenty of other ways in which you can toughen your WordPress installation, too. First, make sure everything—WordPress itself, and any plugins and themes you've installed—is fully up to date. Second, perform an audit of all the plugins you have installed: Search for reviews to check they're legit, make sure you only install through the WordPress website, and remove those you don't need or use to free up resources. Once that's done, you're ready to make your WordPress site more resilient to hijackers and other malicious attacks. **–NICK PEERS**


A
Current one-time password (update)
016893
QR code
Private key - always to be kept secret - type this into your app to set it up (instead of scanning the code)

1 HARDEN LOGIN

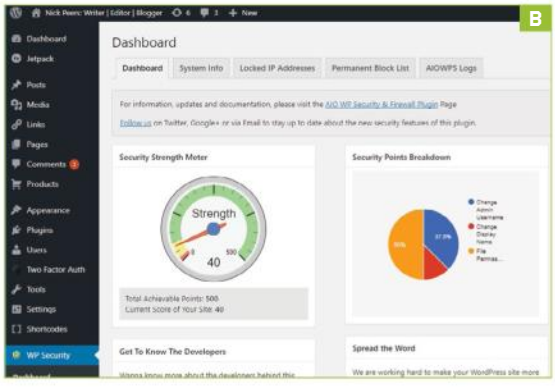
Log in to WordPress, navigate to "Users → Your Profile," scroll down, and click "Generate Password" to create a strong random password. Copy this somewhere safe (such as to your password manager), and click "Update Profile."

» Next, let's set up two-factor authentication, which means that even if someone breaks your password, they can't log in to your account without your mobile device and a suitable app, such as Google Authenticator or LastPass Authenticator. Go to "Plugins → Add New," and install Two-Factor Authentication from David Nutbourne. Click "Activate," click the plugins icon to enable it, then scan the QR code into your mobile app [**Image A**].

2 INSTALL ALL-IN-ONE PLUGIN

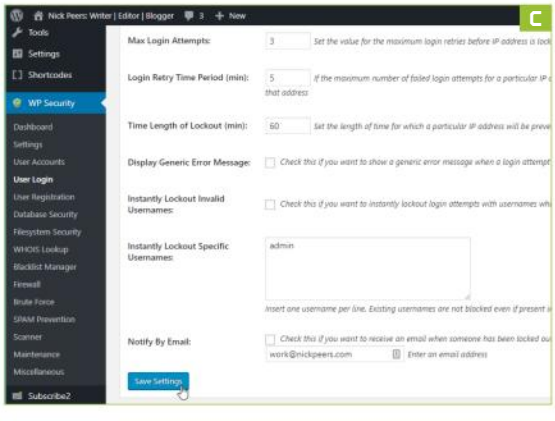
Go back to "Plugins → Add New" to install All In One WP Security & Firewall, a 100 percent free plugin from Tips and Tricks HQ, which contains all the tools required to add multiple layers of security to your account. Once activated, look for the green shield icon in the left-hand pane, and click it. You're whisked to a dashboard with a handy Security Strength Meter. Chances are its score is incredibly low [**Image B**].

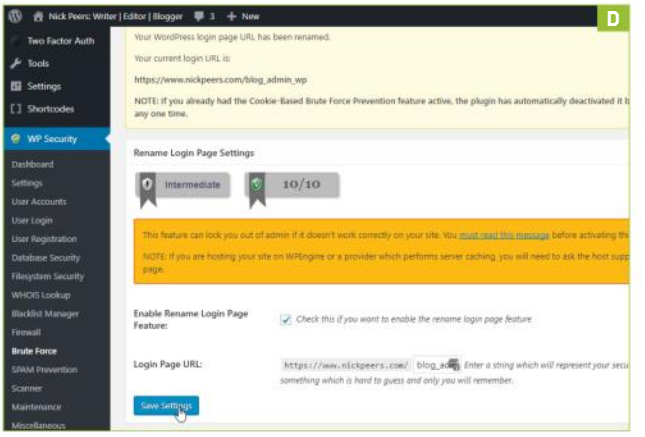
» Start by scrolling down to the Critical Feature Status. These four switches need to be on, so click the first one, which allows you to change your username from the unsafe default ("admin") to something more personal. Click the switch, then click "Edit User" to change your username. Also, switch to the "Display Name" tab to make sure that your display name isn't the same as your username.



3 REDUCE BRUTE-FORCE ATTACKS

Return to the main dashboard and click "Login Lockdown." Start by checking the "Enable Login Lockdown Feature." This allows you to block specific IP addresses when they attempt—and fail—to log in. You have control over the number of failed attempts, and the time in which those attempts occur, plus how long the IP address





is locked out. You can also instantly lock out attempts using invalid usernames, although a safer bet may be to add "admin" to the specific username list [**Image C**], now you're no longer using it. Click "Save Settings." You can be notified by email whenever an IP address is locked out, or just check the "Failed Login Records" tab.

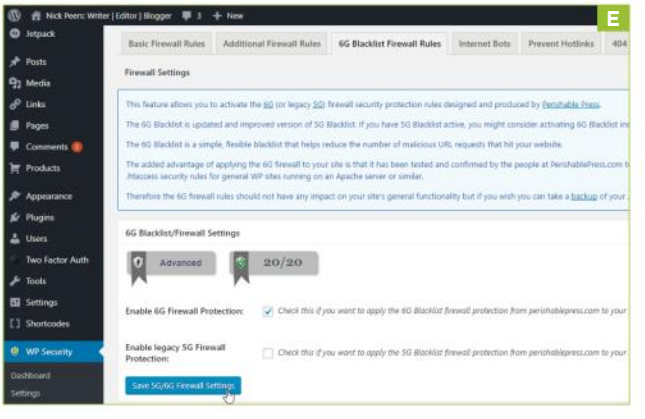
4 ELIMINATE BRUTE-FORCE ATTACKS

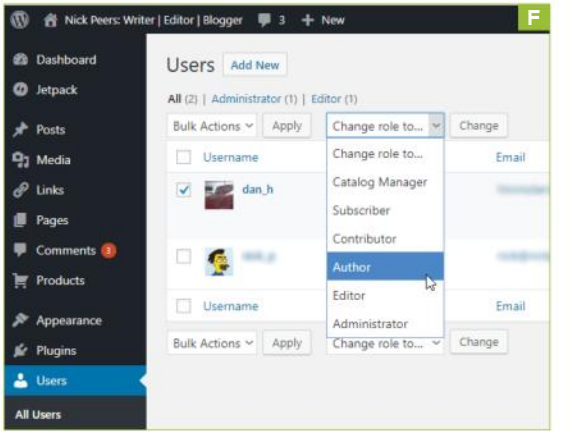
Go further by restricting the opportunities for brute-force attacks. Select "Brute Force" under the WP Security icon, where you'll find several options for keeping hackers away from your site. Some can be potentially dangerous—"Rename Login Page" is one such option, but so long as you remember the name you give your wp-login.php page, you won't have any problems [**Image D**]. Other options include using cookies to block brute-force attempts, and a "Login Whitelist" tab, where you can restrict access to specific IP addresses or ranges. If you're tempted by this option, be sure to check with your Internet provider that your public IP address is static, or you'll end up locking yourself out when it next changes.

5 MORE ESSENTIAL TWEAKS

Click "File Permission" to review the current permission settings of your WordPress installation files. Hopefully, they're correctly set to prevent outside interference, but if not, you can click "Set Recommended Permissions" next to any that require it. Also consider disabling PHP File Editing, if you don't normally edit these files.

›› Next, select "Scanner" to perform a check for file changes. This is a benchmark scan, so no problems will be detected—going forward, enable the automated file change detection scan to be alerted to any changes that could indicate the presence of malicious activity. The "Malware Scan" tab merely redirects you to a paid-for solution that provides a more robust scan for $6.95 a month.





6 SWITCH ON FIREWALL

Finally, click "Basic Firewall" to switch on the firewall, but click the link allowing you to back up your .htaccess file first—just to be on the safe side (this is backed up to your web space, so you need to download it using FTP or via your site host's control panel). Review the other options, too—for example, blocking remote access to the debug log file still allows you to access it when logged on through FTP. Also consider enabling the 6G Blacklist Firewall Rules [**Image E**]. Note, if any plugins stop working, either disable features or consider replacing them with similar plugins that do play nicely with your hardened blog.

7 LIMIT USER ACCESS

If your blog is used by more than one person, make sure you're the only Administrator, and grant the minimum level of access required to other users for them to do their jobs. WordPress supports a wide range of user roles [**Image F**]—for those contributing to your blog, consider Author or Contributor to limit them to posting and managing their own posts. For trusted users, Editor allows them to manage other posts as well. Some plugins add additional levels—WooCommerce adds a Catalog Manager level, for example.

FORCE SECURE BROWSING

Protect yourself further by encrypting the connection to your blog using the secure HTTPS protocol, insulating you against malicious scripts, protecting data submitted to your site by visitors or customers, and improving search engine rankings.

You need an SSL certificate to encrypt the connection, and this is done through the provider hosting your WordPress blog. You can purchase an SSL certificate, but check to see if your provider supports free certificates from Let's Encrypt. If it does, you can encrypt your website for free—note that Let's Encrypt certificates need renewing every three months.

Once set up—you may need to wait a few hours for DNS servers to update—install the Easy HTTPS Redirection plugin into your WordPress installation. Once installed and activated, switch it on under "Settings → HTTPS Redirection." If you later get warnings about insecure content, install and use the SSL Insecure Content Fixer plugin to resolve them.

Make Perfect Rips of Your CDs

YOU'LL NEED THIS

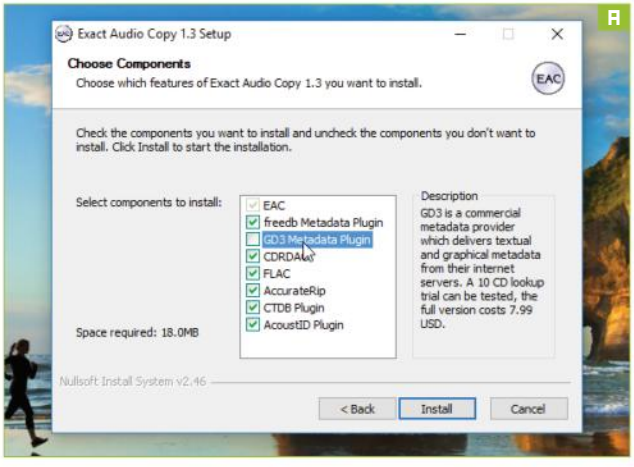
AN OPTICAL DRIVE
Most drives should work just fine—USB or internal.

SEVERAL AUDIO CDS
You need multiples to validate your drive's intricacies.

EXACT AUDIO COPY
From www.exactaudiocopy.de.

OK, GRANDPA, it's time to trash that dusty old CD collection, or at least consign it permanently to a box in the garage, by shifting it all to a purely digital format. But if you're going to go through your whole collection, it pays to do it right the first time, and that means ripping to a lossless format in a way that accurately replicates your discs. Once it's there, you can do as you like with it; had you filled a hard drive with 128Kb/s MP3 files, you'd inevitably have to go through the whole task all over again later on.

Our format: FLAC. Not only because it's lossless and doesn't introduce any compression artefacts, but because a same-res rip is up to half the size of the PCM WAV files that raw CDs carry. We'll use Exact Audio Copy, which can both rip to FLAC and generate the relevant CUE files to perfectly duplicate a CD. It can also compare your rips against a database of known good rips, to ensure your captured sounds are 100 percent sound. Note that ripping CDs is neither explicitly allowed nor disallowed by 1947's copyright-defining Title 17 (funnily enough), but if you keep them to yourself, you should be OK. –ALEX COX


A
Exact Audio Copy 1.3 Setup
Choose Components
Choose which features of Exact Audio Copy 1.3 you want to install.
EAC
Check the components you want to install and uncheck the components you don't want to install. Click Install to start the installation.
Select components to install:
EAC
freedb Metadata Plugin
GD3 Metadata Plugin
CDRDAO
FLAC
AccurateRip
CTDB Plugin
AcoustID Plugin
Description
GD3 is a commercial metadata provider which delivers textual and graphical metadata from their internet servers. A 10 CD lookup trial can be tested, the full version costs 7.99 USD.
Space required: 18.0MB
Nullsoft Install System v2.46
< Back
Install
Cancel

1 INSTALL IT

Download Exact Audio Copy from www.exactaudiocopy.de (making sure to choose the English-language version, rather than the German default), and run the installer. Click through until you're able to select which components to install, and deselect "GD3" [**Image A**], unless you're OK with paying $8 for track information that you can get for free from the other two services already built in to EAC. Finish clicking through the installer, then run EAC when prompted.

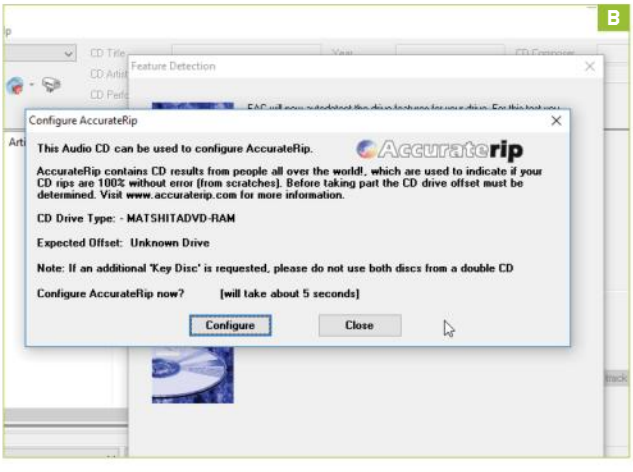
2 WIZARDING WORLD

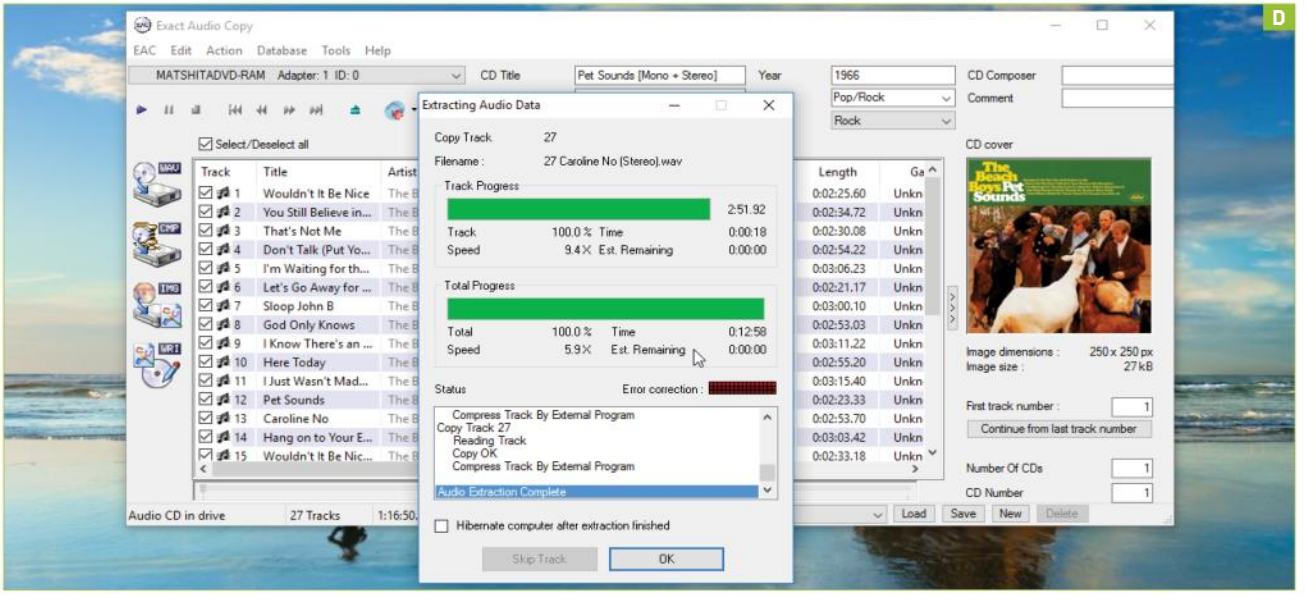
There's a wizard to get through now, but it's a good one—it sets EAC up just about perfectly. First up: configuring your optical devices. If you have more than one drive, you can select which one to use for ripping, although we recommend allowing EAC to configure both at this point. Different drives have different characteristics, and one may turn out to be better than the other in terms of stability and accuracy—given that an ultra-accurate rip is our goal, the better your drive the better.

›› But wait: Configuring your drive involves inserting a disc, and when you do, you'll likely be interrupted by an alert [**Image B**] to set up AccurateRip. This service calculates the specific offsets of your drive's laser, in order to compare the precision of your rips with others online. This part's a bit finicky—it asked us for three subsequent "key discs" after the original, and summarily rejected anything that may have been pressed more than once. So, you might need to search the more obscure corners of your collection to satisfy AccurateRip. It's not essential, but it's worth doing.

3 FURTHER CONFIGURATION

With AccurateRip out of the way, EAC's own drive inspection can complete. Don't panic if it looks as though EAC has crashed at this point. It probably hasn't; give it a couple of minutes to complete. If it's still spinning its wheels after that, you have permission to panic. When the results arrive, ideally you're looking for caching to be a "no," accurate ripping to be a "yes," and C2 error information as "yes"—if these prerequisites aren't met, you can still rip, but your digital copies might not be as accurate as they could be. Continue on through the wizard, and select FLAC when given the option of ripping formats, insert an email address (literally any email address will do, it doesn't have to be valid) to link EAC to the Freedb track metadata service, and set your track naming scheme. Leave EAC in beginner mode for now.


B
Feature Detection
Configure AccurateRip
This Audio CD can be used to configure AccurateRip.
AccurateRip
AccurateRip contains CD results from people all over the world!, which are used to indicate if your CD rips are 100% without error (from scratches). Before taking part the CD drive offset must be determined. Visit www.accuraterip.com for more information.
CD Drive Type: - MATSHITADVD-RAM
Expected Offset: Unknown Drive
Note: If an additional 'Key Disc' is requested, please do not use both discs from a double CD
Configure AccurateRip now? (will take about 5 seconds)
Configure
Close



4 TEST IT OUT

Before we rip our first disc, there's a small amount of additional configuration to do. Hop up to "EAC → Compression Options," and open the "External Compressor" tab. FLAC should be set up by default; hit the "Test Compressor" button to ensure the FLAC encoder is properly installed and working, and to automatically set the appropriate value in the bitrate box. Note that this won't affect your eventual rips, because they'll exactly match CD resolution. Next, head to www.pastebin.com/EVHsFtWm and paste the parameters we've squirreled there into the "Additional command line options" box, to ensure that every file is tagged properly with as much information as possible.

5 LET HER RIP

Time to actually turn a CD into some FLAC files. Drop a target disc into your drive, head back to the main interface, and check the button on the top bar that looks like a CD with a red plus button next to it. Click the drop-down button next to it, and you'll be able to select your metadata provider from one of two Freedb sources (realistically, there's nothing between them) and CueTools DB. Select the latter for now, and click the button to drag in a bunch of information about your disc, including the cover. If it's been released a number of times, you'll want to select your specific version here [**Image C**]. When your track information has populated, click the "CMP" button on the left of the interface to start ripping your FLAC compressed files.

6 CHECK, CHECK

There's not much you can do but watch the bars while the ripping process completes [**Image D**]. Don't be concerned by the mention of .wav files at the top of the ripping window, because EAC pulls these down first before converting them to FLAC, and it does away with them afterward. When everything's complete, you're shown your results, first from AccurateRip (if you've made it though the arduous testing process), and then from CueTools DB. Here you can discover just how well your rips landed, and find out about any dropped frames or errors encountered during the process. And that's it, although if you're concerned about the discs more than the tracks on them, you may wish to try using the "CUE" button on the left of the interface to generate a single massive .wav file with an associated .cue that exactly replicates the contents and track spacing of the original CD.

GOOGLE MUSIC AND SPOTIFY

Good news: Google Music accepts FLAC files, as long as your rips are broken up into tracks rather than in one enormous file. Bad news: They're converted to MP3 as soon as they get there, and your source FLACs aren't stored. It's not the worst thing in the world, as Google does keep perfectly listenable 320Kb/s copies of your originals as long as the resultant file is smaller than 300MB, but it's not suitable for backup if you're concerned about staying lossless.

Spotify, which streams Ogg Vorbis files, doesn't play nice with FLAC. You need to double up and convert your FLAC files to MP3 or Ogg Vorbis using a tool such as FlacSquisher (http://sourceforge.net/projects/flacsquisher) to add them to your library locally, and the service is yet to make good supplying its teased hi-fi streaming tier to all but a few select testers. When it does, we expect local FLAC support to roll in, too, but there's nothing confirmed as yet.

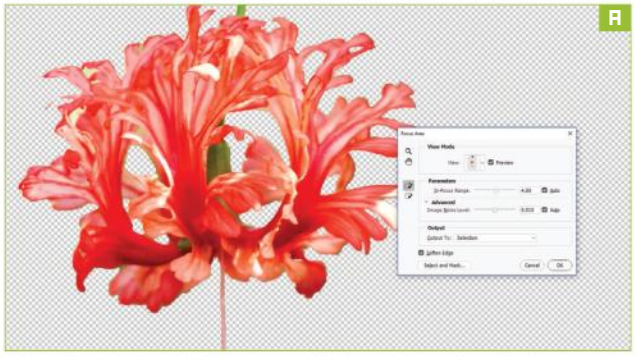
Create Artistic Blur in Photoshop

YOU'LL NEED THIS

ADOBE PHOTOSHOP
Subscribe to a suitable package at www.adobe.com.

PHOTOGRAPHERS SPEND A LOT OF TIME ensuring their pictures are sharp—thousands of dollars' worth of autofocus system will help you out, but there's slightly more to it than that, just as cranking open your aperture may decrease your depth of field, but also introduce some softness to your subject, unless you're using the latest lenses, which can be mind-blowingly expensive.

Blur is an aesthetic issue, and as such, is subjective. Where one person may see the beauty of a small subject enhanced by a blurred background, others see a missed opportunity to show us what's there clearly. This is where post-processing comes in. Photoshop has many tools to add blur to your images—some subtle, others less so—and even one to select areas of your image depending on how sharp they are. You can get enormously artistic with them, creating a masterpiece of blurred colors and details, or just ensure your subject pops out of a photo by blurring a distracting background away. The choice is yours. –IAN EVENDEN



1 FIND YOUR FOCUS

Selecting the sharp parts of your image is achieved with the Focus Area tool from the "Select" menu. This is a largely automated tool, with just a couple sliders to fiddle with, and selectors to add and remove areas from the selection. Open your image file, and choose "Select → Focus Area." It gives your CPU fan a quick blast of speed, then settles down to show you the sharp areas of your image. You can choose how this is displayed from the "View Mode" drop-down on the "Focus Area" pop-up window, with the red of a Quick Mask or the checkerboard background of an empty layer available, along with other options.

2 IN A SNAP

The Add and Subtract tools to the left of the pop-up window are for adding to or removing areas from your selection. We left the two sliders on "Auto"—there's a checkbox on the right of them—and used "Add" and "Subtract" to fine-tune the selection [Image A]. You can output the selection in a variety of ways, but we've chosen the traditional selection with the marching ants outline. Hit "OK." You can then refine the selection further with "Select" and "Mask," perhaps softening the edge with a little feathering, or turning on "Smart Radius" edge detection to snap the selection more tightly to the edge of your subject [Image B].

3 GO POP-EYED

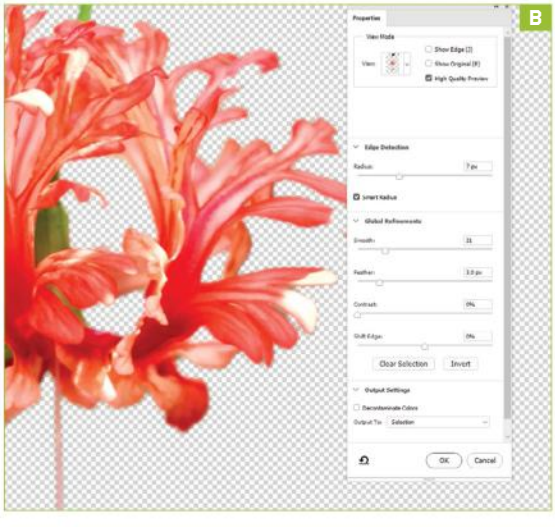
Invert your selection with "Select → Inverse," and you now have the unsharp areas selected. To make the sharp subject pop out, we can blur the background as if we'd used a larger aperture setting on the lens when we took the photo. This is useful for cell phone cameras whose depth of field capabilities are limited by tiny sensors and short focal lengths, even though some have pretty good light-gathering capabilities, with lens apertures of f/1.8 or wider.

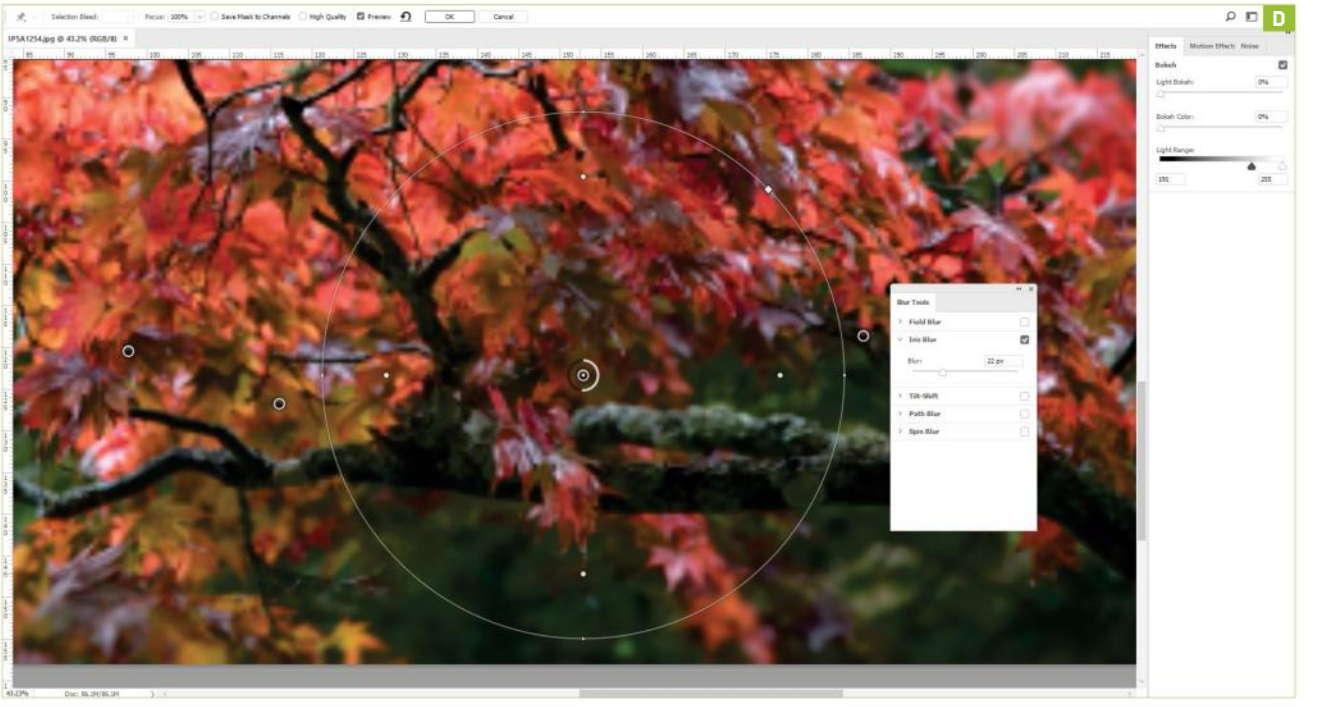
4 PIN POINTS

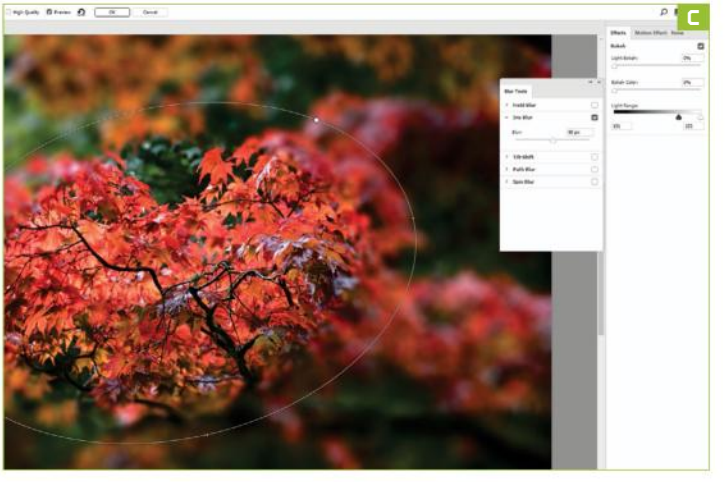
From the "Filter menu," select "Blur Gallery," then "Field Blur." This filter uses control points, or pins, to differ the intensity of the blur in different areas of your image. We've started at the top with a strong blur, then lightened it as we proceeded down the side of our flower, before strengthening it again at the bottom , but you can do whatever suits your image best. Use the slider on the Blur Tools palette to increase or decrease the intensity. You can move your pins by dragging them with the mouse, or delete them by selecting one, and hitting Backspace.

5 GET BUSY WITH THE BLUR

As we made a selection before applying the filter, you can place a pin right on top of an area you want to remain sharp, and as long as it's outside the selected area, the blur has no effect—what does happen is that the effects of that pin are felt in the area between it and







THE ROLE OF PIXELS

Pixels are, of course, the basic building blocks of any raster display technology, but Photoshop uses them in a slightly different way when it comes to blurring or sharpening your images. Tools such as Unsharp Mask measure the intensity of their effect in pixels, because increasing the slider increases the distance the application looks for differences in contrast between pixels that may constitute an edge. Sharpening your image increases this contrast, and it becomes more obvious the greater the number of pixels that are counted as edges. Blurring an image, on the other hand, evens out the contrast, and averages the pixels over a greater or lesser area, depending on how many pixels you have chosen to select via the slider. In brief, more pixels means more of an effect, no matter whether you're sharpening your image or blurring it.

the next pin, anywhere that was selected. You can even place a pin outside your image if needed, to draw the right amount of blur across the corner of the photo. Hit "OK" at the top when you've finished blurring, and a progress bar appears while your blurring is rendered and finalized.

6 EYE-CATCHING EFFECTS

Another of Photoshop's blur tools that's worth looking at is the Iris Blur, which is found in "Filter → Blur Gallery," just underneath "Field Blur." It's useful for blurring the edges of an image, so attention is drawn to the focal point or subject. In this way, the eye of the observer is guided to where you want it to look, rather than catching on some insignificant detail elsewhere.

7 ADD INTEREST WITH IRIS

Iris Blur places an oval over your image, and blurs everything outside of it, plus a little inside, as defined by a series of draggable spots. There's only one control slider, for the intensity of the blur, so it seems there's not a great deal of depth to this tool—until you discover that you can place more than one oval. These are positioned using a pin system, just like Field Blur's, each with an oval surrounding it, which can be rotated, resized, and repositioned as you like.

8 NATURAL BEAUTY

The outer ring of the oval marks the point at which the blur reaches 100 percent of its intensity, as set in the Blur Tools palette [**Image C**]. The inner ring marks 0 percent, and there's a smooth transition between the two. This means you can have a sharp transition or a longer one, depending on the look you're trying to achieve [**Image D**]. It's easy to create something unrealistic here by using too much blur, or making the transitions between blurred and unblurred too sudden. To keep it natural, try combining both Iris and Field Blur, to gently soften the background of a photo, while maintaining the sharpness of the subject.

Stop Sites Tracking Your Online Activity

YOU'LL NEED THIS

WINDOWS 10
You need the latest version of the OS, with Microsoft Edge.

GHOSTERY
Grab this browser extension from www.ghostery.com.

MANY OF THE WEBSITES you visit are tracking you by placing small files, called "cookies," on your computer. This helps them gather information about your browsing habits, and target you with advertisements. Data collection tools (known as "trackers") can be very intrusive. If you wanted a quote for life assurance, for instance, would you want an insurance website to know that you'd been browsing books on Amazon about quitting smoking?

Luckily, a Microsoft Edge browser extension called Ghostery can help stop you being tracked online, blocking communications with such companies, while still enabling you to surf the web. Better yet, it displays a handy purple list of companies that have tried to track you, as well as what information they're after. Install it today to make sure your web history stays private, and keep monitoring it regularly. –NATE DRAKE

1 UPDATE WINDOWS 10

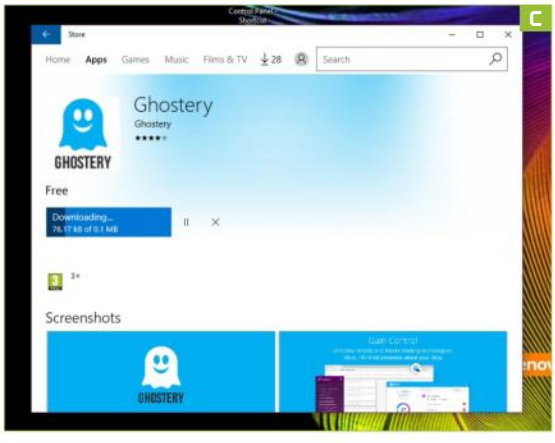
Ghostery needs the most recent version of Windows to work. Save and close any open files, and back up your data if possible. Next, click the search button at the bottom-left of your desktop, and enter "Windows 10 Upgrade Assistant." Click on the desktop app to open it. Click "Yes" to confirm that you wish to open the app, then "Update Now" to begin upgrading your system [**Image A**].

2 VISIT THE GHOSTERY WEBSITE

Once the update is complete, open Microsoft Edge, and visit www.ghostery.com. Hover your mouse over "Our Solutions," and click "Ghostery Browser Extension." A new screen appears, listing various web browsers. Scroll down until you see "Edge." Click "Add to Edge" [**Image B**], and the Windows Store opens. Quit Edge, then click the button marked "Free" to install.

3 BEGIN GHOSTERY DOWNLOAD

At this stage, Ghostery may ask you to confirm your date of birth and region. Enter this and click "Next." The Windows



Store now says "Acquiring License," then "Downloading" [**Image C**]. The Ghostery extension is small (0.1MB), so this doesn't take long. Finally, the Store tells you that the product has been installed. The button below the Ghostery logo now reads "Launch." Click this to open Edge.

4 WELCOME TO GHOSTERY

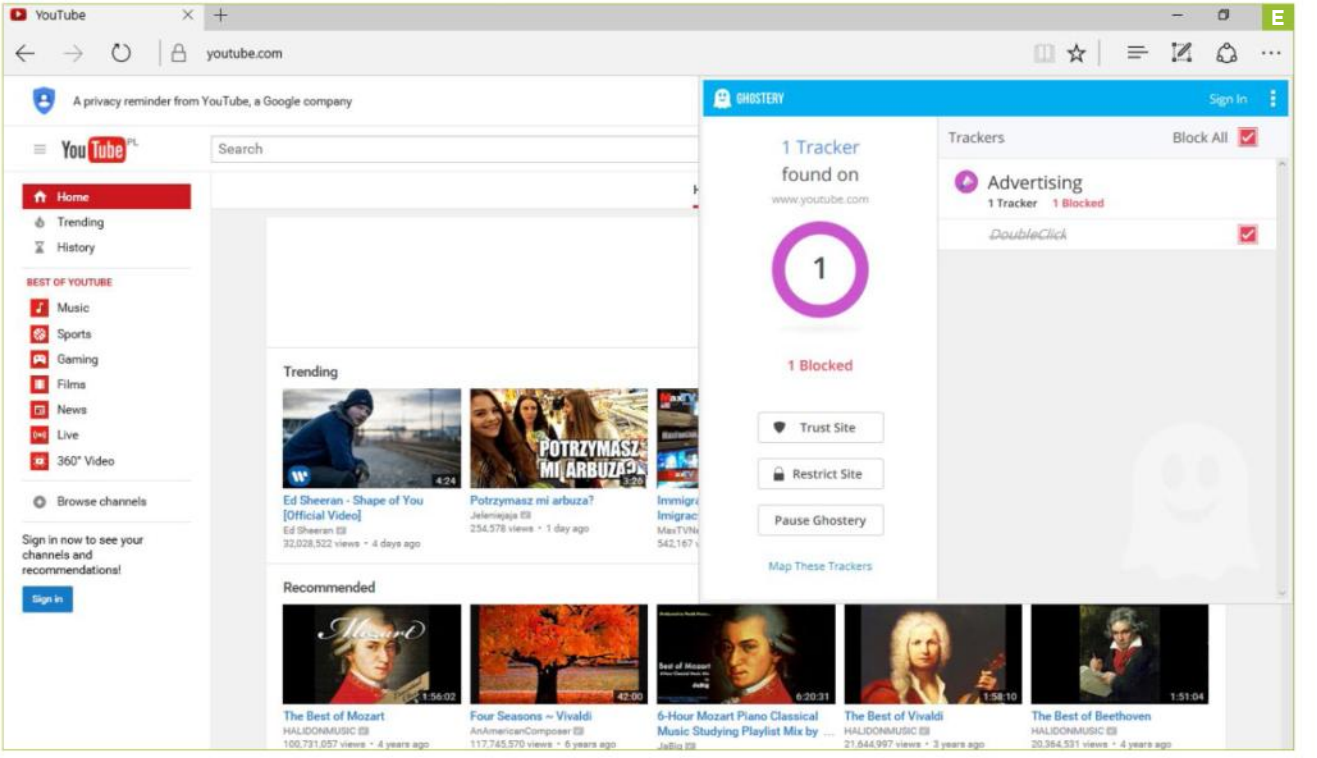
A notification appears at the top-right, explaining that Ghostery has been installed. You still need to activate it, so click "Turn it on." You now see a "Welcome to Ghostery" splash screen. At this stage, Ghostery asks you if you wish to share data about trackers you encounter while browsing. This is entirely optional, but helpful to detect new threats. Choose "Yes" or "No" as you see fit.

5 CREATE AN ACCOUNT

Ghostery now displays the Create an Account window. You don't have to do this, but it allows access to extra features, such as synching settings across your devices. You're also allowed one free trackermap scan per month, to help you locate companies that are tracking you across the Internet. If you don't want to create an account right now, click "Maybe later, let's get started."

6 CHOOSE YOUR TRACKER OPTIONS

Ghostery now launches the main Tracker Options window [**Image D**]. Scroll down to see various types



of trackers that Ghostery can detect, such as Advertising and Social Media. The easiest option for now is just to click on "Block All," to ban all trackers. If this causes issues later, you can return to this screen by clicking on the "More" option in the Ghostery box, then "Advanced Blocking."

7 CHOOSE WHAT TO BLOCK

Click on the word "General" next to "Blocking Options." Most options can be left checked. However, you may wish to scroll down to the Purple Box section. By default, Ghostery displays a small box for a short time when you visit a new site, listing all the trackers that have been blocked. You can switch this off, or change the duration (default is 15 seconds) and position of the box here.

8 CONFIGURE TRUSTED SITES

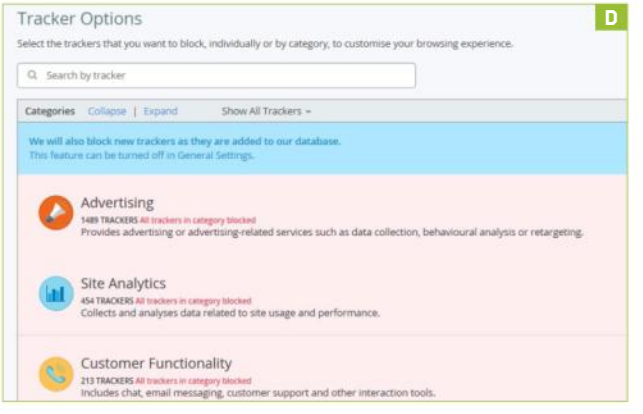
Although you can visit sites individually, and click Ghostery's "Trust Site" button, it's easier to set this up here. Click the "Trusted Sites" option at the top of the page. Once it loads, enter the name of the website in the white bar at the top, then click on the green "+" button. Repeat the process for any websites you fully trust. Hover over a website, and click the "X" to remove it from this list at any time.

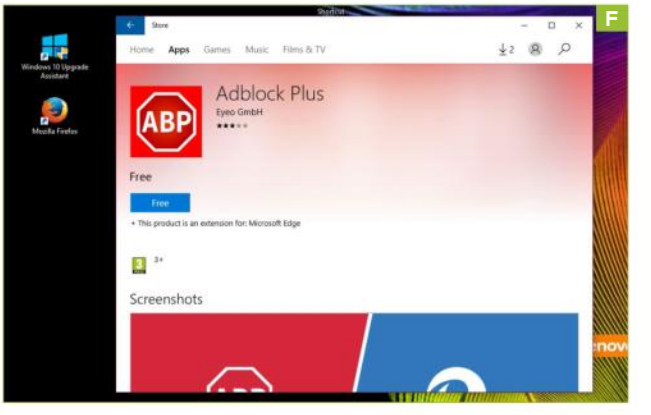
9 TEST-PILOT GHOSTERY

Once Ghostery has been set up, click the address bar at the top, and visit a social media or news site to check that everything is in order. If the purple box doesn't appear, click the ellipsis (...) button at the top-right of the Edge window, then "Ghostery App" to view any blocked trackers [**Image E**]. You can enable individual trackers, or choose to trust the entire site, allowing all cookies.

10 INSTALL AN AD BLOCKER

Although Ghostery can prevent websites from tracking you, it can't stop all pop-up ads, or those annoying ads that load when you're trying to watch YouTube. Fortunately, Adblock Plus is also available for Microsoft Edge. Open the Windows Store, search for its name, then install [**Image F**]. This reduces the chance of accidentally clicking a link, and downloading malware.


D
Tracker Options
Select the trackers that you want to block, individually or by category, to customise your browsing experience.
Search by tracker
Categories Collapse | Expand
Show All Trackers
We will also block new trackers as they are added to our database.
This feature can be turned off in General Settings.
Advertising
1489 TRACKERS All trackers in category blocked
Provides advertising or advertising-related services such as data collection, behavioural analysis or retargeting.
Site Analytics
454 TRACKERS All trackers in category blocked
Collects and analyses data related to site usage and performance.
Customer Functionality
213 TRACKERS All trackers in category blocked
Includes chat, email messaging, customer support and other interaction tools.



BUILD IT

ZAK STOREY, DEPUTY EDITOR

Editorial Upgrades

We're not even sure what happened to this rig, but with lots of TLC, we injected it with a new zest for life

LENGTH OF TIME: **1–2 HOURS** | LEVEL OF DIFFICULTY: **HAZARDOUS**

THE CONCEPT

UPON OPENING THE CHASSIS and dodging the cloud of dust containing every respiratory disease known to man, we bore witness to the true horror of an unloved PC. The panels, once standing proud, pristinely showcasing the hardware within, sheared off the side of the case with an eerie screech, the filth and grime breaking free as the thumbscrews gave up their long vigil protecting the beating heart of the machine inside. Fan blades littered the floor—the slow ravages of hard time in this technological gulag had stripped the polypropylene scythes from their housings. As once free-moving bearings glinted in the ephemeral twilight of the photography studio, we began to realize that this was unlike any horror we'd witnessed before.

The executive editor's PC lay in ruins. Working hard, day in, day out, for years on end, to produce one of the world's best-selling custom PC magazines, it was a rig that had suffered much. Yet all was not lost; this was not the end for the BitFenix Shinobi. Its pseudo Japanese-German heritage would live on, we would make sure of that.

The challenge that lay before us was undeniably daunting. Even though it was only five years of age, this machine had been through a lot. And with its vast arsenal of computational prowess within, once the pride of its generation, now falling defunct in its dotage, it stood in stark contrast to the other mechanical mammoths beavering away in the *Maximum PC* office. The task at hand was simple: Sanitize it, gut it, and install the latest available hardware, bringing the lumbering beast of burden back to glory, to bear its might upon the transistor-fused world once more.

CLEANING THE UNCLEAN

RIGHT! Now we've got that out of the way, let's talk about what we're replacing in our executive editor's machine. This isn't a simple new build, but more of a core upgrade to some legendary componentry. And, while we're at it, an attempt to retain that old, beaten chassis—because, y'know, we're sadists.

This machine once hosted an Intel Core i7-3820 quad-core 32nm processor, 16GB of quad-channel DDR3, an Asus X9 X79 Pro motherboard, a Sapphire Radeon R9 390 GPU, a half-working Thermaltake 240mm AIO CPU cooler, a 250GB Samsung 840 Evo, and a 3TB WD Red hard drive.

To keep things fairly simple, and encourage good system maintenance, we've opted for a few more industrially centered components to power the magnificent Shinobi and give it a bit more processing grunt. It may be powering a 1920x1200 screen (yep, one of those), but that's no reason to deny it the juice to deal with more demanding titles destined to come out in the future.

We've gone for an Intel Core i7-7700K running at stock, a dual-channel kit of 16GB DDR4, one of PNY's GTX 1080 XLR8 cards, and a Gigabyte Z270X-Ultra Gaming mobo. But the more important changes come in the form of cooling. This time, instead of a liquid cooler, we've gone for one of Noctua's NH-C14S towers, paired with two Noctua NF-A14 IP67-rated, dustproof, industrial-grade 140mm fans. We've also included four 120mm EK Vardar Evos: one at the front, in the 5.25-inch drive bay, as an intake; two in the roof, exhausting; and one in the rear, also acting as an exhaust. We've also kept the massive 230mm BitFenix Spectre in the front, because it's still too good an offer to pass up.

INGREDIENTS

PART		STREET PRICE
CPU	Intel Core i7-7700K	$315
Motherboard	Gigabyte Z270X-Ultra Gaming ATX	$155
Memory	16GB (2x 8GB) Kingston HyperX Fury 2666	$170
GPU	PNY GeForce GTX 1080 XLR8	$540
Exhaust Fans	4x EK Vardar Evo 120ER Black	$79
CPU Cooler	Noctua NH-C14S	$75
CPU Fans	2x Noctua NF-A14 IPPC 2000 140mm	$46
Tinned Air	Dust-Off Compressed Gas Duster—2 Pack	$9
Isopropyl Alcohol	Swan Isopropyl Alcohol 99%	$9
Total		$1,398

1 SYSTEM MAINTENANCE

IT'S STAGGERING THAT this liquid cooler worked as long as it did, diligently cooling the Core i7-3820 for almost five years. However, it does illustrate how imperative it is to give your rig a good clean once in a while. Dust, grime, and condensation are major killers for hardware like this, and keeping your CPU cool should be one of your top priorities. We're not saying go crazy on the cleaning, but every three to six months, take your rig outside, and take a can of compressed air or even a foot pump to it, to get rid of excess dust inside the chassis. In fact, this is why we recommend windowed cases, so you can avoid the "out of sight, out of mind" philosophy.

2 STRIP DOWN

UPGRADING A CORE SYSTEM is much like building a new rig. In this case, we started by taking a can of compressed air and attempting to blow out as much of the dust as we could. Then, we removed as many panels as possible, before doing the same again, and began to remove the cooling after that. This gives you the opportunity to grab a microfiber cloth and clean up any fans going back in, along with the areas on which they were mounted. We replaced a lot of the fans, so it was less of an issue, but if you're reusing them, it's not a bad idea to clean off the blades in particular, before installing them back into the chassis.

3 OUT WITH THE OLD

AND IN WITH THE NEW. Now we're talking. Next up, you're going to want to unplug everything from everywhere. You can leave the PSU installed in the chassis, especially in older cases. Then it's a case of removing the old motherboard and installing a new one. It's often easier to install the processor outside of the chassis first. Fortunately, thanks to the Shinobi's massive CPU cut-out, installing the backplate for the Noctua can be done after the motherboard is installed into the chassis. It's also imperative (with this cooler) that you install the memory now, too, because the cooler will cover all the slots.

4 COOLER MANAGEMENT

SWAPPING OUT FANS on these kind of coolers isn't ever going to be a picnic, especially given the nature of the clips that secure the fans in place. Because this is essentially a second-hand tower cooler, the clips aren't quite as rigid now as they should be. To counter this problem, we used a single cable tie between the top clip on the top fans and the top clip on the bottom fan, to secure them on place. Additionally, to generally tidy up the cables, we've wrapped them into small loops, to reduce mess. Because these fans are technically designed for radiators and case fans, the cables are fairly long, and so require a fair bit of inventive management to ensure they don't get caught on anything.

5 CABLES GALORE

WE'VE GOT TO GIVE CREDIT to BitFenix—the Shinobi XL is nothing if not well equipped. With four USB 3.0 ports and a powered USB port on the front of the chassis, finding places to route all of that front I/O was challenging. Fortunately, the Z270X Ultra Gaming comes packing two USB 3.0 headers just south of the 24-pin. Impressively, we managed to route those two cables, plus the 24-pin, and the single 8-pin PCIe power through a single rubber grommet—and, to be honest, it still looks fairly tidy, too.

6 FINISHING UP

AND THERE YOU GO: one updated, cleaned-out system. We took some isopropyl alcohol to the soft-touch finish in an attempt to try to remove some of the grime and damage from the chassis, but there's only so much you can do with a case this old, unfortunately. And don't worry about that old quad-core Extreme Edition chip—it will be going off to work in a new home in our IT department, happily sauntering on toward retirement.

1 **We ended up using a three-way PWM splitter to power the two fans in the roof and the front of the case, because the mobo didn't have enough headers.**

2 **The Shinobi still had an archaic AC97 audio cable attached to the HD audio cable—take a pair of scissors and cut it off to reduce clutter, and you should be fine.**

3 **This 1,500W PSU is a bit OTT (about seven times too much) for this build, but it would be an unnecessary expense to change it over, and it still works a treat.**

4 **We moved both the hard drive and the SSD to the lowest rungs to allow for better airflow toward the GPU.**

IT LIVES!

IT'S ALIVE! OK, so it wasn't really dead to begin with, we'll admit, but it was certainly in dire need of some TLC. The Intel Core i7-3820 at its heart was an intriguing part for its time. Competing directly with the Core i7-2700K, it made little sense in the PC ecosystem, much like Intel's current Kaby Lake X parts do. A quad-core Extreme Edition processor, back in the 32nm days? Odd. That said, it served its purpose, and played all the latest games and the programs needed to produce a magazine without a hiccup.

The build process, despite the excessive levels of dust and blackened hands we ended up with during construction (we're still not sure what caused that; mold probably), was a relatively painless process. Using compressed air helped a ton with the initial clean-up, and after removing the fans and going over the whole build with a microfiber cloth, it started to resemble a new chassis again. We have to give credit to BitFenix's design team from back in the day, because this case is still fantastic to build in. Especially if you have a modular power supply. Fortunately, our Shinobi isn't the windowed version, so cable management in this build was less about aesthetics and more about function than anything else.

But it's all about performance, and although neither storage nor memory capacity have changed much with this upgrade, the key components—CPU and GPU—have. And what a difference they've made. Single and multicore performance saw almost a 50 percent improvement in performance, with graphics performance stomping its way up by a massive 100 percent in some cases.

In its day, AMD's Radeon R9 390 was an incredible piece of flagship technology, but comparing it to Nvidia's Pascal architecture is akin to comparing an ant to a cat. The difference is staggering. It's difficult for us, in the short term at least, to quantify just how much of a change the additional cooling solutions have added to this build, especially as we've swapped over processors as well. Hopefully, the IP67 ratings on the CPU cooling fans should ensure they last much, much, much longer than the Thermaltake stock fans that came with the previous AIO.

Things that are still due an upgrade? Outside of the case, there's not a lot. It fits the bill perfectly for the tasks we need it to do. Perhaps a Samsung 850 Evo would make more sense as a primary OS drive, because those read speeds are a little on the slow side, but aside from that, it's all set for another five years of hard labor. At least until the case begins to rot away....

BENCHMARKS

	ZERO-POINT	
Cinebench R15 Multi-Thread	602	870 (45%)
Cinebench R15 Single-Thread	125	184 (47%)
TechARP's X264 HD 5.0.1 (fps)	13.19	21.39 (62%)
CrystalDisk QD32 Sequential Read (MB/s)	532	526 (-1%)
CrystalDisk QD32 Sequential Write (MB/s)	224	227 (1%)
Rise of the Tomb Raider (fps)	37	77 (108%)
The Division (fps)	63	112 (78%)
3DMark: Fire Strike (Index)	57	108 (89%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our zero-point for this build was the system prior to its upgrades, featuring an Intel Core i7-3820, 16GB (4x 4GB) of quad-channel DDR3, a Sapphire Radeon R9 390, and a 250GB Samsung 840 Evo.

We've upgraded

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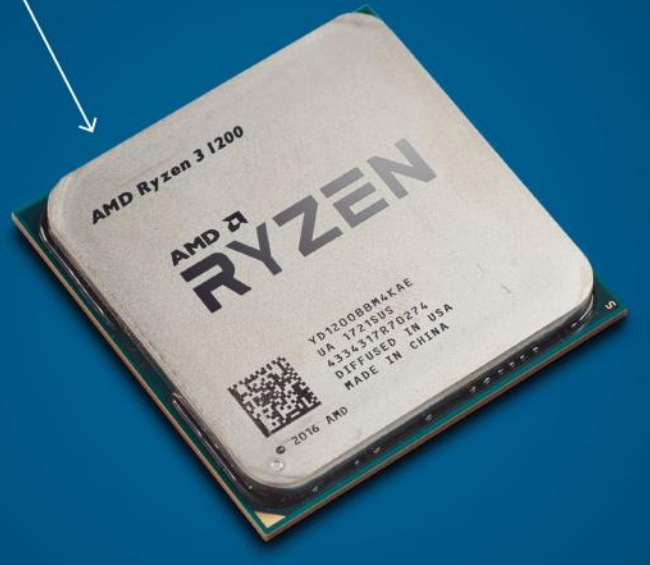
REVIEWS

TESTED. REVIEWED. VERDICTIZED.

AMD RYZEN 3 1200 PAGE 79



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Hey, Asus! Naming scheme—get one that works, please!

Asus ROG Strix GTX 1070 Ti A8G Gaming

The card that should not be

WHY DOES THIS CARD even exist? Let's get one thing straight: Unless you're deep into cryptocurrency mining, this generation's GPU war is over. Nvidia has won. Vega, although powerful, can't compete from a price perspective, and thanks to its horrendous power draw and delayed launch, it's not an attractive proposition for gamers. Vega 56 was the most intriguing offering, slotting between the GTX 1070 and the GTX 1080. And that, presumably, is why Nvidia has brought this card to market. The problem, however, is that in its eagerness to secure every corner of the GPU market, Nvidia has cut off its nose to spite its face. What do we mean? Allow us to explain....

The best way to understand why this card is such a confusing proposition from Team Green is to take a look at the basic specs of the models either side of it. The GTX 1070 touts 1,920 CUDA cores, 120 texture units, and 8GB of GDDR5; the GTX 1080, on the other hand, features 2,560 CUDA cores, 160 texture units, and 8GB of GDDR5X. That's a pretty wide gap, especially with the memory configuration. But when you consider that the 1070 essentially equates to a Titan X of Maxwell's generation, it's fair to say that both cards are attractive offerings for anyone looking to game at 1440p or higher.

The GTX 1070 Ti, then, features 2,432 CUDA cores, 152 texture units, and 8GB of GDDR5. That's a difference of 128 CUDA cores between it and the GTX 1080. To put that into perspective, the difference between the GTX 1060 3GB and 6GB variants is—you guessed it—128 CUDA cores. If you've followed us for a while, you'll know we stand by the GTX 1060 3GB as being the better value card, purely because, in our tests at least, the difference between it and its 6GB brother is just 1–2fps, and that's with half the memory capacity.

INSANE IN THE GAME

It should come as no surprise, then, that in our tests the GTX 1070 Ti and the GTX 1080 perform almost identically, even when compared against some of our more overclock-heavy aftermarket models. The maximum disparity between the two at 1080p was 3fps; 5fps at 1440p; and 4fps at 4K. That's insane when there's about $90 difference in price between the two.

The lines become even more blurred when you enter the realms of overclocking. There were plenty of rumors concerning Nvidia requesting that AIB manufacturers not produce "overclocked" variants of its GTX 1070 Ti. And when you combine that knowledge with the fact that there's an "advanced" sticker covering the word "overclocked" on our Asus GTX 1070 Ti box (no, seriously), well, we'll leave you to be the judge of what's really going on. But the fact is, you can easily add 220MHz on to the core clock, and 350MHz on to the memory, without temperature issues, and end up with scores and performance that actually surpass a stock GTX 1080.

So, is this just a really dumb overreaction to Vega 56? Well, yes and no. We can sort of see the logic behind the design of the card. Firstly, GDDR5X is expensive to produce and in short supply. Secondly, the GTX 1080 has been out for near enough 18 months now—if you were going to buy one, you would have done so already. What you're getting with this is a GTX 1080 at a discounted price, which kind of makes sense. Nvidia gets to keep the prestigious nature of its product line, without calling it a cut-down or discounted GTX 1080, and at the same time, it shores up that extra acreage of market share. It's a smart move, but if you recently bought a GTX 1080, it's a bit of a slap in the face. **–ZAK STOREY**

VERDICT **9**

Asus ROG Strix GTX 1070 Ti A8G Gaming

+ VEGA KILLER Impressive performance; price cut; good overclock headroom; fantastic AIB card design.

– GTX 1080 KILLER Odd marketing strategy; confusing spec.

$500, www.asus.com

BENCHMARKS

	Asus ROG Strix GTX 1070 Ti A8G	Nvidia GeForce GTX 1080 FE	Nvidia GeForce GTX 1070 FE
Total War: Attila (fps)	**24/40**	23/**40**	21/34
Far Cry Primal (fps)	62/72	**65/77**	53/62
The Division (fps)	**58**/72	39/**73**	34/59
Rise of the Tomb Raider (fps)	**21/42**	16/**42**	13/33
3DMark: Fire Strike (Index)	16,914	**17,016**	14,909
3DMark: Fire Strike OC (Index)	17,955	**18,115**	16,160
3DMark: Time Spy DX12 (Index)	**6,684**	6,537	5,542
Power Draw Load (W)	291	**252**	288

Best scores are in bold. Our test bed consists of an Intel Core i7-7700K, 16GB of Corsair DDR4 @ 2400, an Asus Maximus IX Hero, and a 500GB Samsung 850 Evo SSD. All games are tested at their highest graphical profile, with AA turned up, at 1440p.

SPECIFICATIONS

GPU	Pascal GP104-300-A1
Lithography	16nm FinFET
Transistor Count	7.2 billion
CUDA Cores	2,432
Texture Units	152
ROPS	64
Core/Boost Clock	1,607/1,683
Memory Capacity & Type	8GB GDDR5
TDP	180W
Display Connectors	Display Port 1.4, HDMI 2.0b

Origin PC Neuron

Now we're cooking

WINTER IS HERE. Luckily, we have a new heater to keep us toasty through the coldest months of the year. A nice little space heater, and it's even decked out with some sweet RGB lighting. Oh, and it's a massively powerful gaming system, too.

We're talking, of course, about the Neuron, a high-end microATX custom build from Origin PC, outfitted in either a Phanteks EVOLV or Fractal Design Define Mini C case. The system we tested utilized the former, featuring tempered glass panels on convenient easy-open hinges. Inside sits an Intel Core i7-8700K CPU overclocked to 5.0GHz, nestled in a nicely featured ROG Strix Z370 mobo from Asus. Intel's Coffee Lake CPU shines here, able to stably handle Origin's overclock up to 5.0GHz. Origin's Frostbyte 360 liquid cooler keeps CPU temperatures under control, hovering at just above 80 C during intense benchmarking load.

It's a good thing, because the rest of this system is a heat monster. The main offender is the pair of GTX 1080 Ti GPUs stacked on top of each other in SLI. They're a beast for gaming performance (more on that later), but also generate a ton of residual heat under intense load. We measured temperatures of 80–85 C both inside the case (measuring the outer panel of the top GPU) and pouring out the blower fans out back while playing games at 4K Ultra. These are well within normal GPU range, of course, and won't throttle your performance, but it was still enough heat to warm our office up a little. In a brief moment of genius/insanity, we decided to see whether we could cook an egg inside. The easy-open tempered glass panels functioned like an oven door as we popped an egg into a tin foil container on the GPU stack. It took about an hour, but the food did cook. You've had eggs over-easy—we call this eggs over-clocked.

POWER OVERWHELMING

While it can pull double-duty as a backup breakfast oven, the Neuron's primary function is that of an extreme gaming PC. That should be expected, with a pair of top-end GTX 1080 Tis handling GPU duties, but it was still impressive to see in person. We ran all of our gaming benchmarks at 4K, using the highest available graphics preset, and the pair of monster cards did not disappoint. In *Rise of the Tomb Raider,* the Neuron averaged 99fps across the three-part benchmark, returning 125fps in the Mountain Pass, 91fps in Syria, and 81fps in the Geothermal Valley. More demanding was *Total War: Warhammer II,* which we tested using DirectX 11 and the Battle benchmark. The score there was 76fps, again at 4K max settings.

Most demanding was *Ghost Recon: Wildlands,* a game that often cripples single-GPU systems, even when running at only 1080p. The Neuron was up to the challenge, but just barely, scoring 53fps using the Ultra preset—at 4K, of course. With a slight bit of tinkering, that number should stay above 60 without a problem. We also tested all three versions of 3DMark Fire Strike: The Neuron scored 34,380 in the regular Fire Strike test, 22,909 in Fire Strike Extreme, and 13,283 in Fire Strike Ultra, corresponding to performance at 1080p, 1440p, and 4K respectively.

Unrelated to performance, but very impressive all the same, are the elegant RGB touches Origin has added to the already great Phanteks EVOLV case. All the components are tucked away tidily, while a strip of LEDs adorning the viewing panel gives everything a cool, pulsating, moonlit glow. This light show co-ordinates nicely with G.Skill's Trident Z RGB RAM, an application of RGB lighting we thought was ridiculous on paper, but actually looks pretty awesome in person.

All in all, we were very impressed with the Neuron, even if it does run a little on the hot side. Boasting top-end components (and a price to match), it'll do just about anything you ask—including cook you breakfast. **–BO MOORE**

VERDICT 9

Origin PC Neuron

EGG-SEMPLARY Overclocked CPU; insane GPU power; super-quick storage; clean, beautiful design.

SULFURIC Excessive heat output; very expensive.

$4,395, www.originpc.com

BENCHMARKS

	ZERO-POINT	
Cinebench R15 (Index)	196	218 (11%)
Cinebench R15 Multi (Index)	987	1,587 (61%)
PCMark 8 Creative (Index)	7,675	10,592 (38%)
CrystalDiskMark 4K Read (MB/s)	54.85	60.00 (9%)
CrystalDiskMark 4K Write (MB/s)	171	240 (40%)
Far Cry Primal (fps)	33	85 (158%)
The Division (fps)	34	94 (176%)
Rise of the Tomb Raider (fps)	9	99 (1,000%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our desktop zero-point consists of an Intel Core i7-6700K @ 4.5GHz, 32GB (2x 16GB) of Kingston HyperX Savage 2666 DDR4, a 256GB Samsung 950 Pro PCIe SSD, and an AMD Fury X GPU.
All games are tested at 4K on the Ultra Preset.

SPECIFICATIONS

Processor	Intel Core i7-8700K @ 5.0GHz
Graphics	2x Nvidia GeForce GTX 1080 Ti SLI
RAM	16GB G.Skill Trident Z RGB DDR4-3000
Motherboard	Asus ROG STRIX Z370-G Gaming Wi-Fi AC
Primary Storage	512GB Samsung 960 Pro PCIe NVMe M.2 SSD
Additional Storage	2x 2TB Seagate 2.5-inch FireCuda Flash-Accelerated HDD RAID 0
Cooling Solution	Origin Frostbyte 360 Sealed Liquid Cooling
PSU	850W EVGA SuperNOVA G3
Case	Phanteks EVOLV with Origin PC RGB LED
Warranty	One-year part replacement & 45-day shipping

Dual GTX 1080 Ti GPUs crush our most difficult benchmarks, even at 4K Ultra.

Ryzen ITX done right.

Asus ROG Strix X370-I Gaming

Pure engineering genius

REMEMBER WHEN RYZEN first launched? The gaudy little underdog pulled the rug out from under Intel's feet with its eight-core masterpieces. It was beautiful, although not exactly smooth. The chips may have been legendary, but the platform was not. Memory issues and motherboard instability caused a lot of problems early on, and the selection of high-end X370 offerings was slim at best.

One form factor that was missing was ITX. And with good reason: Ryzen's a hungry beast. Those eight cores need feeding with a lot of juice, which means most motherboards require a substantial VRM solution to balance out the horrendous level of power Ryzen draws from the wall. The issue, as is common with ITX, is a severe shortage of space. How do you accommodate such a power-hungry chip on a form factor that's already so limited? There have been workarounds, of course, typically from those manufacturers with big R&D budgets. But, most of the time, the ITX form factor is avoided for anything featuring more than four cores.

That's not to say ITX hasn't already been attempted with Ryzen; Gigabyte produced the AB350N Gaming WiFi, and ASRock gave us the X370-Gaming ITX. Both suffered from VRM throttling, however, especially when overclocking the eight-core parts.

Finally, though, we are witness to Asus's Ryzen ITX masterpiece: the ROG Strix X370-I. It's a true marvel of engineering. The huge bank of VRM situated alongside and above the AM4 socket provides a wealth of voltage balancing, without the need to include a large raised PCB, as seen in the company's ROG Impact Intel ITX series. Instead, Asus has shifted its focus away from repositioning the VRMs to reworking the way it manages less integral motherboard components. In this case, it's the audio and M.2 storage. Yep, that LED heatsink sitting just above the PCIe x16 slot is actually a raised chunk of separate PCB, which houses all the audio componentry, and supports the installation of a single M.2 PCIe SSD. It's also situated above a small heatsink that simultaneously cools the PCH chipset. This makes a lot of sense. Typically, to improve audio, motherboard manufacturers introduce a polyethylene separator between the audio componentry and the rest of the motherboard's PCB, to reduce interference from electrical signals on the board. The design seen in the ROG Strix X370-I, where the PCB is entirely separate and raised, is more often found in prosumer-grade DACs, such as the Schiit Gungnir, than in an A-grade motherboard.

Now, we're not saying the audio is going to be that good (there's still an M.2 PCIe SSD on there, too), but it should equate to normal levels of audio quality, while freeing up space on the mainboard for that massive VRM solution.

So, on to performance. The X370-I is nothing short of a beast. We saw better scores here at stock than with any other X370 motherboard we've tested, which just goes to show how far the platform has matured in such a short time. Memory latency has plummeted as well. The only cause for concern we have is with power draw, because it topped our idle figures by 20 watts, and is the second highest motherboard we've tested under load.

But the biggy is overclocking, right? Well, it's a mixed bag here. We only managed a stable 3.9GHz on our Ryzen 7 1800X across all eight cores. 4GHz was just too far out of reach, alluding to the fact that even with all this motherboard magic, ITX still has issues holding higher clocks compared to its ATX rivals.

Asus's ROG Strix X370-I is, ultimately, an impressive entry point to the Ryzen ITX ecosystem. It does have its flaws, but it's easily the best ITX AM4 board you can buy right now, and for that we have to applaud Asus. **–ZAK STOREY**

BENCHMARKS

	Asus ROG Strix X370-I Gaming	MSI X370 Gaming Pro Carbon
X265 (Avg fps)	**28.3**	27.98
Cinebench R15 Multi (Index)	**1,635**	1,622
Fry Render (Seconds)	**152**	158
AIDA64 Memory Latency (ns)	**76**	90
Power Draw Idle (Watts)	81	**56**
Power Draw Load (Watts)	168	**147**
CrystalDisk Sequential Read (MB/s)	**551**	549
CrystalDisk Sequential Write (MB/s)	**530**	523
Far Cry Primal (Avg fps)	**42**	**42**
3DMark: Fire Strike Extreme (Index)	9,600	**9,647**
Maximum OC Achieved (GHz)	3.9	**4.0**

Best scores are in bold. Our test bed consists of a Ryzen 7 1800X, 16GB (2x 8GB) of Corsair Dominator Platinum DDR4 3200, an Nvidia GeForce GTX 1080, and a 500GB Samsung 850 Evo SSD. *Far Cry Primal* tested on Ultra settings at 4K.

VERDICT **9**

Asus ROG Strix X370-I Gaming

OVERPOWERED Impressive design; brilliant aesthetic; acceptable price; huge feature set; strong memory support.

OVERLOADED Power draw; overclocking needs work.

$185, www.asus.com

SPECIFICATIONS

Chipset/Socket	X370/AM4
Form Factor	ITX
Memory Support	32GB DDR4 @ 3,600MT/s
M.2/U.2 Support	2x M.2 PCIe x4
SATA Support	4x SATA 6Gb/s
Max PCIe Support	1x PCIe 3.0 x16
Rear I/O	1x Intel Gigabit Ethernet, 2x USB 3.1 Type A, 4x USB 3.0, three-channel audio, 1x Wi-Fi 802.11 a/b/g/n/ac

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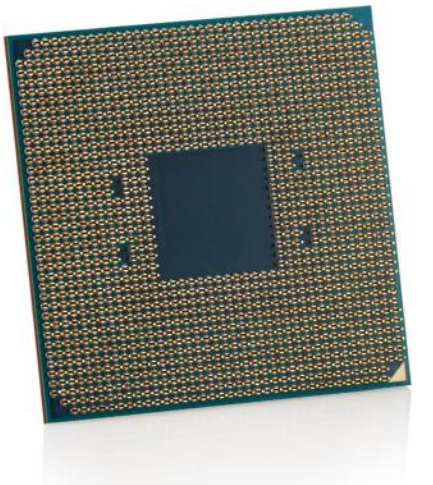
AMD Ryzen 3 1200

The most budget-conscious spin of Ryzen highlights the new multicore norm



IT'S TEMPTING TO START by saying you can't always get what you want, and in lieu of being able to afford a top-flight monster, a budget chip like this will have to do. But questionable Rolling Stones references aside, it's not the whole story when it comes to AMD's most affordable Ryzen chip. This isn't just a chip to turn to when forced to build on a shoestring; it's a chip that shows how far CPUs have advanced in a year, and it's a chip that punches far harder than its $100 price tag suggests.

That single Franklin nets you a true quad-core processor. Yup, the sort of territory that was previously the preserve of a mainstream Core i5. The Ryzen's base clock nominally runs at 3.1GHz, but you'll rarely see it running the cores at that speed; instead it'll operate closer to the Turbo of 3.4GHz. There's no SMT included on AMD's Ryzen 3s, presumably to help separate them from the Ryzen 5 chips, but it's still a speedy chip, capable of handling four threads at once for bang on $100.

It should make for an interesting counterpoint to Intel's new Core i3s, although we haven't had those in our labs yet, so instead we've compared it to the 8th Gen Core i5-8400, purely because that's the chip to beat in the desktop space at the moment. On the face of things, that's not a fair comparison, as the new Core i5 is a six-core, six-thread chip, but it does cost double what AMD is asking for this, so bear that in mind when looking over the specifications and benchmark results.

Speaking of benchmarks, we can report there are no nasty surprises with the Ryzen 3 1200—given the core count and operating frequency, it performs as expected. This means that it's bringing up the rear of the benchmark tables, but it does so at a great price. The Cinebench R15 result of 478, for instance, may seem low compared to the Core i5's 949, but in the context of price, you're looking at a score of 4.78 per dollar, as opposed to 4.75 for Intel's. Yup, you get more bang for your buck from AMD's chip.

It is worth noting that the latest BIOS updates mean that the memory issues we saw at the launch of Ryzen have evaporated, and that getting the system up and running was a breeze. Gaming isn't that big a differentiator anymore either, with a mere 2fps drop over the more expensive chip in *Far Cry Primal*.

You'll find a Wraith Stealth cooler in the box alongside the CPU, and it's a fine cooler at stock performance. It's worthy of its "Stealth" moniker, too. When it came to overclocking, we reached for our AIO cooler of choice, the NZXT Kraken X62, but you should be able to hit decent numbers with the Stealth as well. Overclocking the Ryzen 3 1200 is simple—set the target frequency in the BIOS (up the voltage if needed), and you're done. In this case, we hit a stable 3.7GHz, which saw the Cinebench R15 score jump to 567 points.

Overall, this is a lot of chip for not much money. If you need serious power, you should absolutely spend more, but if value is your main concern, there's certainly a lot to love here. –ALAN DEXTER

BENCHMARKS

	AMD Ryzen 3 1200	Intel Core i5-8400
X265 Benchmark (fps)	11.12	**22.20**
Cinebench R15 Single (Index)	133	**165**
Cinebench R15 Multi (Index)	478	**949**
Fry Render (Seconds)	500	**230**
AIDA64 Memory Latency (ns)	79	**69**
Total War: Atilla (fps)	33	**41**
Far Cry Primal (fps)	75	**77**
3DMark: Fire Strike (Index)	13,339	**15,405**
Power Draw Idle (Watts)	49	**47**
Power Draw Load (Watts)	**98**	112

Best scores are in bold. Our test bed consists of an MSI X370 Gaming Pro Carbon or Asus Maximus X Hero, 16GB (2x 8GB) of Corsair Dominator Platinum DDR4, an Nvidia GeForce GTX 1080, and a Samsung 850 Evo 500GB SSD. All games were tested at 1440p on the highest graphical profile.

VERDICT **8**

AMD Ryzen 3 1200

BUDGET Great value for money; good cooler; true quad-core; easily overclocked.

FUDGE-IT Lacks real raw grunt.

$100, www.amd.com

SPECIFICATIONS

Base Clock	3.1GHz
Turbo Clock	3.4GHz
Cores	4
Threads	4
Lithography	14nm
Cache	8MB L3
Memory Support	DDR4
Memory Channels	2
Max PCIe Lanes	20
TDP	65W

Philips BDM4037UW

It's big, but it ain't beautiful

PC TECHNOLOGY is pretty mature these days. That particularly applies to monitors. Usually, even a cursory perusal of the spec list gives you a good idea of what to expect. So, it's not all that often a screen comes along and blows apart your expectations, but that's exactly what the new Philips BDM4037UW pulls off. Unfortunately, it does so for all the wrong reasons.

On paper, it looks similar to its sibling, the BDM4065UC. That screen has been knocking around for a few years, but offers the same 40-inch diagonal and 3840x2160 UHD native resolution. Both panels also leverage VA technology, and Philips claims similar specifications for everything from contrast to pixel response. Indeed, the only really significant differences involve the BDM4037UW's gentle panel curvature, and the fact that it's a couple of years newer.

The former can be an acquired taste, but is at least a known quantity; that known quantity being a curvature of 3000R, and thus far less aggressive than most curved panels. The latter, you'd think, would, if anything, bequeath the BDM4037UW with a newer, more advanced panel, and perhaps some more refined electronics. That would be no bad thing, given the old BDM4065UC had its fair share of image quality quirks.

Alas, no. The new BDM4037UW is a bit of a disaster. The main problem is what, in this day and age, can only be classified as appalling pixel response. Philips rates the panel at 4ms, versus 3ms for its more elderly sibling. But the gap feels more like a minute than a millisecond. The blurring and ghosting is absolutely grim. Unfortunately, ramping up the pixel overdrive setting in the on-screen menu barely puts a dent in the problem. Of course, VA panels have long suffered from the worst response of any of the major panel types, but it's a while since we've seen anything this bad, and the older, flatter 40-inch Philips has perfectly adequate response.

Another throwback to the bad old days of VA panels is the overly warm color temperature. It's the kind of thing you can mitigate to some degree via calibration. But this is far from the most accurate LCD panel on earth, and you're never going to achieve anything really neutral when it comes to temperature and overall gamut. While we're sticking the boot in, the backlighting isn't particularly strong, either.

What's more, that shallowness of the curvature is such that it feels more like a gimmick than a practical feature. It's a big old screen, so if you're going to buy into the curved panel proposition, why not really go for it? The final image quality demerit involves the viewing angles, which are merely mediocre. To all that, you can add a chassis and stand that look a little cheap and chintzy, at which point you're probably thinking the BDM4037UW has no redeeming features. That isn't quite right.

It boasts impressive contrast, with plenty of detail in black and white scales. It also renders virtually perfect, smooth gradients. Moreover, it's still a 40-inch UHD panel, and that means it's absolutely huge, and has literally millions of pixels. Just over eight million, in fact. That means oodles of desktop real estate, tons of detail, and an epic overall visual impact. What's more, most of the time, that sluggish pixel response isn't actually a huge drawback. It's often not even that noticeable in games.

For those who want a very large screen and lots of pixels above all else, the Philips BDM4037UW holds a certain appeal. It's just not a terribly robust appeal in the context of its $750 price tag. To take one example, Philips' sister brand AOC offers the C4008VU8 with virtually identical specs for $250 less. Put simply, there are better options at this price point. –**JEREMY LAIRD**

VERDICT **6**

Philips BDM4037UW

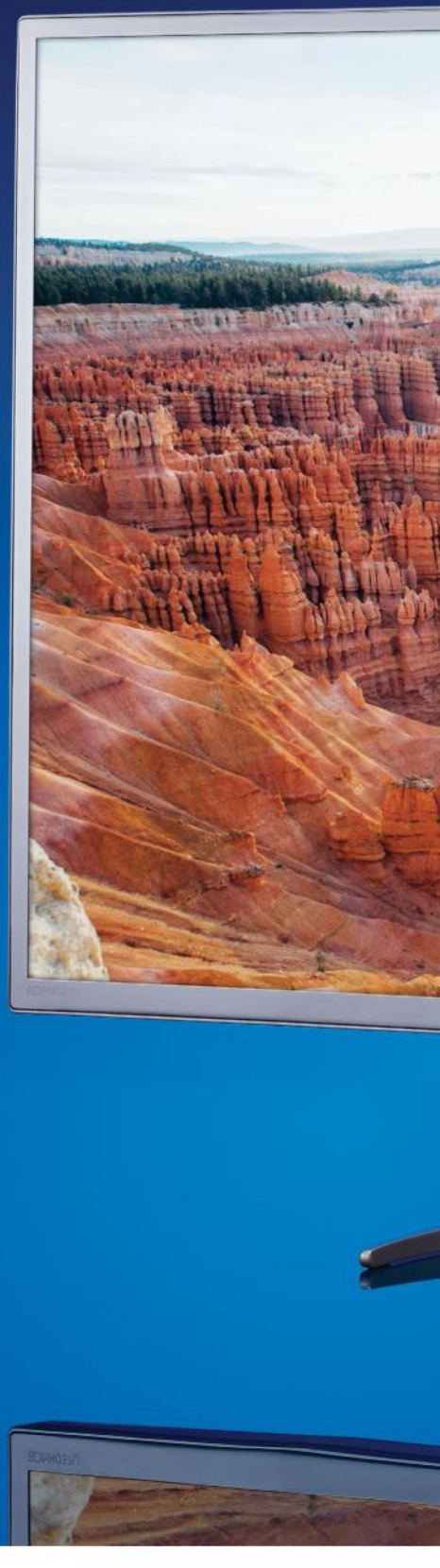
AHEAD OF THE CURVE Huge panel; massive pixel grid; loads of contrast.

JUST PLAIN BENT Awful pixel response; not terribly accurate; pricey as hell.

$750, www.philips.com

SPECIFICATIONS

Panel Size	40-inch
Native Resolution	3840x2160
Pixel Density	110 ppi
Panel Type	VA
Maximum Refresh	60Hz
Response	4ms
Contrast	4,000:1
Display Inputs	2x DP, 2x HDMI, VGA, MHL
Connectivity	USB
VESA Mount	100mm
Warranty	Three years



Philips' new 40-incher suffers from poor pixel response.

Intel Optane is finally here in a form that we can get excited about.

Intel Optane SSD 900P 480GB

Behold a bold new era in data storage

GENUINE TECHNOLOGICAL revolutions don't come along very often, but this might very well be one of them. The new Optane 900P, seen here in 480GB specification, is not the first product we've seen that's based on Intel's radical new 3D XPoint memory technology. But it debuts 3D XPoint in a form that allows a much better chance of delivering on its massive promise.

This is 3D XPoint as a complete, self-contained, high-performance storage solution, rather than a small cache drive designed to help add a little fizz to a larger but slower drive. But what is 3D XPoint? That depends on how you use it. In this context, it's a brand new variant of non-volatile memory that promises to combine the best attributes of an existing non-volatile technology like NAND flash memory, which include solid-state robustness, with the speed of volatile RAM.

Unlike NAND memory, which depends upon trapping electrons in an insulated gate, 3D XPoint uses bulk property change to alter the resistance of each memory cell, which in turn enables bits of data to be stored. The "3D" bit comes in relation to the stacked arrangement of the selector and memory cells, which are then connected by layers of interconnects, the idea being that multiple layers increase memory density. First-gen 3D XPoint involves two-layer technology, but Intel says future iterations will increase density both in terms of the lithography or size of the individual cells, and the number of layers.

Anyway, the upshot is a radically new memory tech that offers massive performance advantages. On paper, at least. With the new Optane 900P, we're getting our first chance for a true feel of what 3D XPoint can achieve in practice. Right from the get-go, what it can achieve is stellar. One of our pre-testing routines—call it a habit if you like—is to completely fill a given SSD with data, then delete it all before beginning testing. It's a crude methodology, to be sure, but it does cut out the possibility, albeit one that applies more to older drives, that an SSD only performs optimal writing to virgin cells.

This usually involves copying data sequentially from a source drive over USB 3.0 at about 300MB/s. Typically, attempting to copy some files over to the test drive and then multiplying them through internal file copies results in a fairly dramatic drop in performance, to 100MB/s or even less. But not with the Optane 900P. It motors along with internal file copies at a full 1GB/s indefinitely, or at least long enough to fill this drive's 480GB capacity. We have never seen anything like it.

Firing up our test suite throws up further impressive figures. The plain and dirty sequential numbers aren't actually all that impressive. Don't misunderstand us—two-point-something GB/s for both reads and writes does not constitute slouchy performance. It's just we've seen similar or even bigger numbers before from several conventional PCI Express SSDs based on NAND memory. Samsung's 960 Pro can do over 3GB/s in certain metrics, for example.

Turn your attention to CrystalDiskMark's 4K random results, however, and you'll see further evidence of what makes Intel's new drive so special. For writes, only Intel's own 750 NAND drive comes close. But for reads, the new 900P tears the entire market a new one—342MB/s is not far off an order of magnitude quicker than any previous SSD. It's also the fastest drive we've seen on our formal internal file copy test, which isn't a huge surprise, given its performance during our pre-benchmark prep.

None of this comes cheap, of course. But then nor do the fastest CPUs and graphics cards. Considered in conventional GB/$ terms, and where good enough suffices, this drive makes no sense. But if you want the best, it doesn't look bad value in the context of $2,000 CPUs. **–JEREMY LAIRD**

VERDICT

9

KICK ASS!

Intel Optane SSD 900P 480GB

+ TEAR IT UP Sets new performance standards in many areas; based on radical new storage technology.

– IN PIECES Seriously expensive compared to conventional SSDs; not the fastest by every single metric.

$600, www.intel.com

BENCHMARKS

	Intel Optane SSD 900P 480GB	Samsung 960 Pro 2TB	Intel SSD 750 Series 1.2TB
30GB Internal Copy (Seconds)	**30**	41	42
Atto Sequential Read (MB/s)	2,724	**3,420**	2,645
Atto Sequential Write (MB/s)	**2,303**	2099	1,431
CrystalDiskMark Sequential Read (MB/s)	2,546	**2,636**	1,298
CrystalDiskMark Sequential Write (MB/s)	**2,159**	2,077	1,271
CrystalDiskMark 4K Read (MB/s)	**342**	57	37
CrystalDiskMark 4K Write (MB/s)	317	194	**326**

Best scores are in bold. Our test bench consists of an Intel Core i7-7700K, an Asus Maximus IX Hero, an Nvidia GeForce GTX 1080, 16GB of Corsair Dominator Platinum DDR4, and a Samsung 850 Evo 250GB OS SSD.

SPECIFICATIONS

Capacity	480GB
Interface	PCI Express
Control Protocol	NVMe
Controller	Intel SLL3D
Memory Type	Intel 3D XPoint
Sequential Read/Write	2,500/2,000MB/s
Read/Write IOPS	550/500K
Warranty	Five years

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Razer BlackWidow Tournament Edition Chroma V2

Yellow it from the rooftops!

RAZER'S YELLOW SWITCHES are paradoxical: at once very cool and really odd, super practical and annoyingly finicky, luxurious and squishy. We, frankly, didn't like them one bit, but it's not hard to tease out their practical benefits. They're silent, for a start; the only sound you'll hear is the unavoidable tap of a key bottoming out, and a little soft rubbing of the actuation shaft. For those with nearby ears exasperated by the audible click of, for example, Razer's own ridiculously loud green switches, this is a boon. The springs don't ring, even if you give the base of the board a solid whack—one of our biggest keyboard bugbears slashed through on the list. They're also incredibly sensitive. There's no debounce delay, thanks to Razer's upgraded transmission technology, and the company claims a 0.0mm distance between the actuation and reset points, and just 1.2mm travel to actuation. With a meager 45g pressure required to overcome the force of the springs, and no tactile bump, this keyboard feels as though you could type just by breathing heavily near it.

Damn, though, we did miss that bump. While there's still definite feedback coming from the springiness of the keys, their light nature means errant keypresses are incredibly hard to avoid, particularly if you're sporting heavy fingers and questionable motor skills. And the feedback that's there really isn't that great either. It's spongy, bouncy, soft—everything mechanical keyboards shouldn't be. If it weren't for the light touch of its linear mechanism, we'd have whispered quietly that this was even moving toward the experience of typing on a dome-switched keyboard. Smooth, silent, and mechanical may be your dream combination; it absolutely wasn't ours.

The TE Chroma V2 has a lot going for it, even if those switches are contentious. It's tenkeyless, giving it a tight footprint, but that amputation hasn't left it lacking on the scales, as this is a heavy, unmoving slab of a keyboard. Its small size makes it inherently portable, as does the removable USB cable, and your lighting preferences (set via Razer's moderately awkward, but generally very useable, Chroma app) are stored onboard, so they'll follow you wherever you happen to be, and sync with your other devices when you're at home.

Unlike earlier entries in the BlackWidow series, the keyswitches are slightly recessed above a white background, which makes the awesome RGB colors really pop. There's a wrist rest, which carries the spongy theme beyond the keyboard. It's fat—too fat, perhaps, depending on the position your tendons have seized themselves in after years of keyboard abuse. Nonetheless, it's very comfortable, and clicks soundly to the front of the TE V2 magnetically, as long as you don't have the keyboard's fold-out feet extended. When raised, the attraction isn't as strong.

There are times when reviewing tech feels a little cruel—sitting here as an unashamed fan of the clack, mashing stoically away at a squidgy keyboard, intensely disliking the experience of doing so, and having to crush the hard work of some of the brightest engineers in the field by telling you so. Particularly when the BlackWidow TE Chroma V2 is, in no uncertain terms, a brilliant keyboard, brilliantly designed, brilliantly bright, heavy, and thick, and crafted to be perfect for just the right user. The expertise and care that's gone into it shines through, the upgrades from the previous generation all make sense. It's an awesome thing. Objectively, it's a win. Subjectively, it really isn't. The wash of post-review separation anxiety isn't there. All because of a little keyswitch; had this thing thumped on to our reviews desk with Razer's loud, physical, visceral, excellent green switches, or even the bumpy-yet-silent orange variety, it would have been a whole different story. Maybe if the yellow switched version hits your desk, the same will be true—but that's for you to decide. **–ALEX COX**

VERDICT **7**

Razer BlackWidow Tournament Edition Chroma V2

HUNTSMAN Solid engineering; great lighting; super-sensitive response.

DADDY-LONG-LEGS Deeply unpleasant yellow switches.

$140, www.razer.com

SPECIFICATIONS

Switch Type	Razer Yellow
Form Factor	Tenkeyless
Media Keys	Shared with F-keys
Macro Keys	Customizable
LEDs	Full RGB
N-Key Rollover	10-key
Pass-Through	None
Dimensions	1.5 x 18.7 x 6.7 inches
Warranty	One year

Logitech MX Master 2S

A precision-pointing desktop heavyweight

THIS IS THE IPHONE X of mice. Let us explain: When a new Apple phone comes out, packed with features, and highfalutin suits get wind of their colleagues getting one, IT departments the world over get tickets demanding an upgrade. Denial often results in mysterious breakages, previously functional iPhone 7s making their way down flights of stairs or under Lexus tires. If the appearance of this mouse on desks doesn't cause a rise in fraudulent pointing device button-snapping or latte spillages, we'll be surprised.

Not that it's the perfect mouse for everyone. For example, the MX Master 2S lacks the Lightspeed connection tech that's been exciting us so much recently, falling back on Logitech's older Unifying Receiver module—still perfectly speedy and OK for gaming, but not the twitchy winner that gamers crave. Unless you configure it, there's no DPI switching on the mouse itself, with that function transplanted instead into Logitech's Options software suite. The molding defiantly pitches it solely at right-handers. Fans of light mice may also be dissuaded. This is a heavy thing that really feels it; it glides smoothly and calmly, responds in a slick manner, tracks almost deliciously. We're not entirely sure of the physical reason for its catamaran-style base, other than looking a bit cool, and separating the sensor and associated functions from the wing pieces—the MX Master 2S moves perfectly well without any additional aerodynamics.

WHEEL OF FORTUNE

It's the features that'll make it so business-attractive. Let's move down from the top. Two acoustically independent main buttons, completely separate from the main upper shell. A rubberized, but not sticky, metal mouse wheel, weighted and smooth, with the option to switch between ratcheted and freewheeling modes. That ratcheting isn't a physical thing, either—hit a button, and it electrically activates a mild catch; spin the wheel fast, and the ratchet disengages, dropping back into place when you're done spinning. Sounds weird, but splitting fast scroll facilities with the knowing chunk of a clicky wheel feels really good.

On the left edge, there's a syrupy smooth thumb wheel, useful for scrolling side to side, or any other function you want to configure it for. Behind that, realistically too far behind to comfortably reach with your thumb, is a pair of sliver-thin buttons that we'll skirt over, because this is the bit where we tell you what's great about the Master MX, and they're really quite awful. On the thumb rest, a hidden gesture control button. Down the wire—an entirely optional USB connection, useful only really when charging—is the aforementioned Logitech Options driver, which lives up to its name with a cornucopia of configuration choices. Further on from that, Logitech Flow, a multiplatform rip-off of Synergy, which enables you to seamlessly move the MX Master 2S's cursor between multiple machines, even going so far as to copy and paste between them. You can hook up several devices without it, too—the mouse itself saves configuration of up to three individual machines, either via the Unifying Receiver or Bluetooth.

It's an absolutely gimmick-laden package, then, in a well-built, attractive, comfortable shell. It's easy to see how those features would be highly attractive to creatives, professionals, and desktop users, and inspire scurrilous envy in those who don't get to play with them. It really is an iPhone mouse. But like Apple's handsets, it brings with it a couple of negatives. First, the ecosystem: Unless you're happy to stick with the stock settings, you absolutely must use Options, and we had a couple of issues with software crashes and incompatibility on our travels. Second, something of a narrow focus. Those side buttons are almost unusable, and the thumb wheel is of questionable value to all but a specific sector. The MX Master 2S does more than enough to deserve the "Master" designation, but a few design tweaks might have seen it earn an even stronger superlative. –ALEX COX

VERDICT **9**

Logitech MX Master 2S

MASTERPIECE Flexible software; great feel; highly practical configuration.

DISASTERPIECE Useless side buttons tied to software.

$100, www.logitech.com

SPECIFICATIONS

Sensor	Logitech
Sensitivity	4,000 dpi
Sensor Model	Darkfield High Precision
Polling Rate	8ms (125Hz)
Programmable Buttons	7
LEDs	One, on base
Battery Life	70 hours
Cable Length	1m Micro USB (optional)
Weight	5.1oz

NZXT H700i

Enthusiast-grade case with a CAM-do attitude

IT ONLY TAKES ONE LOOK at the H700i to figure out that this case isn't messing around. Technically, you could build a super-efficient Core i3 system on a microATX board within its roomy chambers, but you wouldn't be fulfilling the purpose for which it was designed. A tempered glass side panel, flashy LED strips, and a central CAM fan controller are all intended for high-end systems to be housed within, and shown off like a gaudy museum exhibit. Unsurprisingly, the pricing follows suit: At $200, is it worth the outlay on your already expensive build?

First things first: It looks great. Aesthetic judgements are never unanimous, but the atmosphere of quiet reverence in the *Maximum PC* office as we unboxed the H700i speaks for itself. The simplicity of its front panel and mesh-free top work well with the full tempered glass side panel to create an unfussy, angular look. Our review sample is plain black, but white, blue-black, and red-black options are also available should you wish to color co-ordinate your GPU, motherboard, and the like. The roomy look of this model is facilitated by some smart internal design—it's easy to keep cables tucked away and components positioned neatly. The PSU is fitted under a shroud at the base of the case, which also has three mounting brackets for 2.5-inch SSDs. In fact, there's room for seven 2.5-inch drives in total—although, to our eye, installing a drive in each of those bays would compromise the clean look quite a bit. Two are on top of the PSU shroud, and another is on the side wall, facing out toward the glass panel as a showcase piece.

It's also a huge case. The CPU and GPU clearance heights are 7.2 inches and 16.2 inches respectively, which is about as roomy as you'll find anywhere in the market. In addition to giving plenty of space for multi-GPU builds without compromising airflow, it also allows ease of access when you're building inside the case. We installed a 120mm air cooler during our test build, but liquid coolers are equally at home in the H700i, thanks to its many radiator mount slots. There's room on the front and top panels for a radiator with three 120mm or two 140mm fans, and plenty of elbow room to fit them, too. Despite the sleek panels, absent of mesh, the airflow is decent within those panels. Three fans fitted to the front and one at the rear disperse the hot air amply.

While we're on the topic of airflow and cooling, it's time to touch upon the H700i's big selling point: a central fan and LED strip controller. The four included fans are all connected to this controller, as are the LED strips along the glass panel side of the case. The controller's connected up by SATA and USB cables, and neatly positioned behind a central pillar on the far side of the case—whose panel can be popped off with one handy button press. Connecting additional fans is therefore straightforward—hook them up to the controller rather than on to the motherboard directly. Some users have reported problems with the CAM software since the H700i's launch. Certain firmware updates have rendered the whole controller useless in some cases, although by the time of publication, it's entirely possible that subsequent firmware updates will have remedied that. That said, Corsair has been running similar systems without the need for additional software for several years now, although admittedly without LED support.

Happily, that's the only stumbling block. Elsewhere, it's plain sailing, from the ease of access when building to the quality of its construction and overall appearance. It's right up in the nosebleeds when it comes to pricing, and does everything you'd expect such an expensive model to do. It's worth researching the state of play on that fan controller before taking the plunge, though, and we only wish there were a cheaper variant, sans smart CAM technology. –PHIL IWANIUK

VERDICT 8

NZXT H700i

WHAT'S NZXT? Superb build quality, great looks; clever cable management.

XT STAGE LEFT The fan controller is a little problematic.

$200, www.nzxt.com

SPECIFICATIONS

Form Factor	Full tower
Motherboard Support	Mini-ITX, microATX, ATX, and EATX (up to 10.7 inches)
Colors Available	Black, white, black & blue, black & red
Window Available	Yes
3.5-Inch Support	3
2.5-Inch Support	7
Radiator Support	Front: 2x 140 or 3x 120mm with push/pull; Top: 2x 140 or 3x 120mm
Fan Support	Front: 3x 120 or 2x 140mm (3 Aer F120 Case Version included); Top: 3x 120 or 2x 140mm; Rear: 1x 120 or 1x 140mm (1 Aer F140 Case Version included)
Dimensions	9.0 x 20.3 x 19.4 inches
Graphics Card Clearance	16.2 inches
CPU Tower Clearance	7.2 inches
Weight	27lb

Photoshop Elements 2018

Adobe's image-editing app gets yet another update

OFFERING PHOTO EDITING for newcomers, the enthusiastic amateur photographer, or even those pros who don't care about things such as CMYK or 16-bit color, Elements has long punched above its weight. Offering 90 percent of Photoshop's most useful features for a fixed price, rather than an annual subscription, and available as a standalone app or in a bundle with its video-editing brother, Premiere Elements, Photoshop Elements is one of the best ways to get into "proper" image editing, rather than playing with filters and emoji.

The Elements interface remains unchanged since version 11, released in 2012. The shift to a year in the app title, rather than a version number, makes it a bit easier to tell how old your version is in future, which can only strengthen the urge to upgrade to the latest annual release.

So, you get the familiar troika of Editor modes—Quick, Guided, and Expert, plus eLive for help and inspiration, and Camera Raw for developing raw files—to choose from, depending on what you want to do and your own skill level. As is often the case, new features are mainly found in Quick and Guided, although Expert does benefit from a new auto-selection tool that should take some of the frustration out of selecting areas with detailed edges.

It works well; dragging a square around an object in your image triggers a short pause, followed by the familiar marching ants outline of a selection. We tried to confuse it with a brown bear against a brown backdrop, but it homed right in on what we wanted. There was a bit of backdrop retained between the bear's legs, but nothing we couldn't sort out with a few clicks.

Elsewhere, there's the ability to open eyes that were blinking when the photo was taken—as long as you have another photo of the same person with their eyes open—and a whole lot of guided edits for replacing backgrounds, creating double exposures, and more.

Then there's Auto Curation. The Organizer half of the app—which, as you've probably guessed—organizes your photo collection, has benefitted from face detection in the past, but now gets new powers to choose the best out of a group of photos. It's activated with a simple checkbox at the top-right of the Organizer interface, and as you might expect, is quite processor-intensive, especially if you import a large photo library. The app also creates a slideshow from the photos Auto Curate selects, so you can show off your skills to family and friends with little to no interaction on your part. It's worth reviewing the system's choices yourself, however, as we found it tended to choose pictures so similar as to almost be duplicates. Sure, they were good photos, but we only needed to see each one once.

Elements gets better every year, but the changes are never big enough to make current users upgrade immediately. For new users, it's a compelling package, but Affinity Photo, the challenger to Adobe's crown, is less than half the price for a package that concentrates on editing, rather than organizing and automation.

For its target audience, Elements 2018 is the best all-round photo-editing app, with the auto-selection tool taking away one of the biggest frustrations many new users find with Expert mode, and the new Guided edits enabling spectacular transformations of your photos, while gently teaching you how the app works. As long as you can stomach the price, it's hard to go wrong. **–IAN EVENDEN**

VERDICT 9

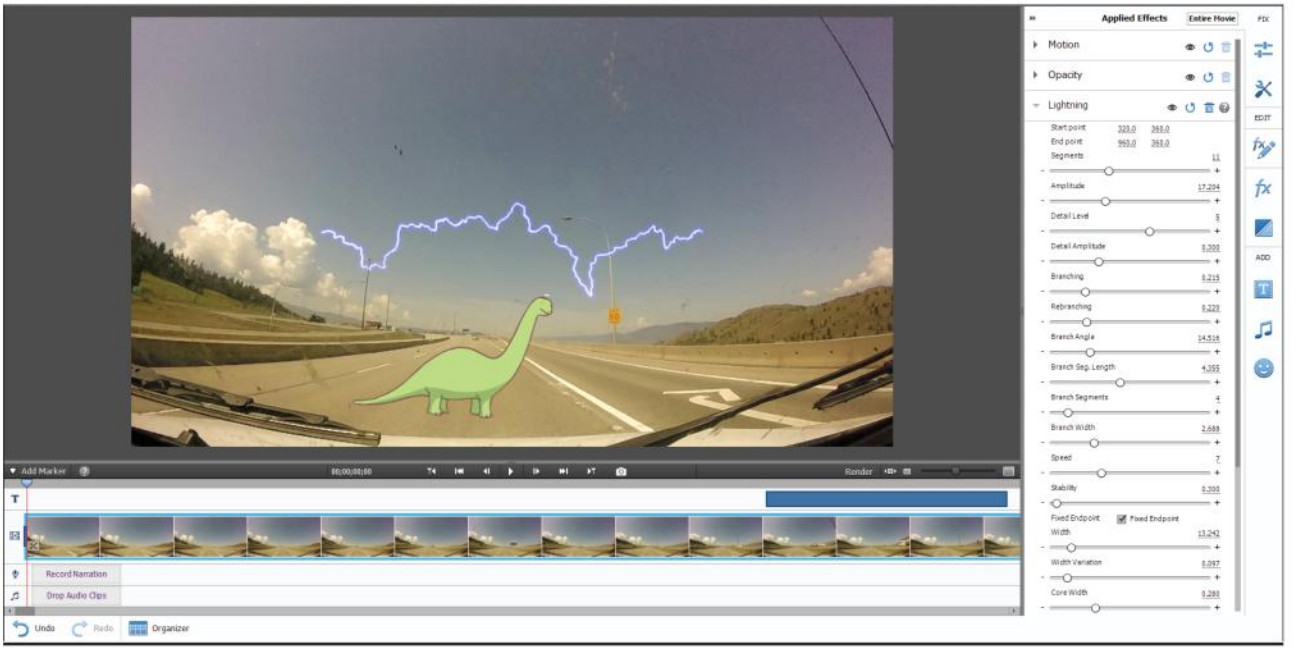
Photoshop Elements 2018

SPECTACULAR Clever new features; tried and tested basics; user-friendly.

VERNACULAR Looks expensive when viewed against the competition.

RECOMMENDED SPECS 1.6GHz or faster processor with SSE2 support; 4GB RAM; 64-bit Windows 7 or newer.

$100, www.adobe.com



Premiere Elements 2018

Channel Howard Hughes with the latest video app

VIDEO EDITING is a skill that comes with practice and study, but Adobe seems determined to slacken the learning curve if this latest release of its beginner-friendly movie editor is anything to go by. However, with a plethora of free apps available online, is it worth using a paid-for one?

Much like its brother across the page, Photoshop Elements, the additions to this 2018 addition are heavy on the automatic processing and time saving. It even claims to be able to teach you video editing.

The interface remains much the same, with a preview window up top, timelines below, and fixes and effects on the right—maddeningly for Photoshop users, who will want them on the left. It's an old-fashioned look now, with the icons appearing too large. The app is split in three, with Quick, Guided, and Expert modes, plus eLive and the Organizer. Quick gives you a single video timeline, plus two audio ones, for quickly chopping up a movie you've made with a single camera, such as your cell, while Expert adds more video tracks, and opens up the number of effects available.

Adobe's machine-learning and AI research is starting to come to fruition, and it shows in this release of Premiere Elements. Similar to the Organizer's Auto-Curate, Auto Trim assesses your video and cuts it into just the best bits. This is likely to produce a result that needs to be looked over by human eyes, as the software can't know what was important when shooting, but it does a reasonable job of discarding bits where nothing much happens, and you can customize the algorithm to focus more on people or action.

Then there's Candid Moments, which hunts through your footage for the best single frames to pull out and treat as still images, even opening them in Photoshop Elements for you. You're probably going to want to be shooting 4K footage to take best advantage of this feature, and it's support for this high-res format, although not a new feature, that marks Premiere Elements out above the slew of free editing apps, many of which top out at 1080p.

What Elements does well is to take the hassle out of video editing. Despite strong showings from developers such as Avid, Wondershare, and Lightworks, the beginner-friendly nature of Adobe's app is one of its strongest features. The Organizer, shared with Photoshop Elements, makes it easy to import and locate your raw footage, then in Guided mode you can learn how to fix it up, be that by removing the distortion inherent in movies shot on action cams (a new feature), or improving a dull-looking clip with tweaks to brightness, color, and contrast. Adjustment layers, familiar to Photoshop users, make it easy to apply the same adjustments or effects to multiple clips, and you can record narration directly into the app, rather than importing it from elsewhere. There's a full suite of DVD menus, titles, and captions for you to play with, and the Time Remapping tool lets you experiment with slow or fast motion.

Video editing can be daunting, and for beginners and advanced amateurs alike, the value of an app that holds your hand, but isn't afraid to let go when you want to run free, is huge. If you only shoot one or two movies on your cell phone a year, a package like this may be overkill, but for anyone with ambitions that include multiple cameras, soundtracks, or animated graphics, you're not going to find much better out there, even if the price may give you pause for thought in the face of free competition. **–IAN EVENDEN**

VERDICT **8**

Premiere Elements 2018

OSCARS Comprehensive video-editing solution; new automated features.

RAZZIES Expensive compared to competition; interface looks clunky.

RECOMMENDED SPECS 1.2GHz CPU with SSE2 support; dual-core CPU for HDV or AVCHD editing; Intel Core i7 for XAVC-S; 4GB RAM; 64-bit Windows 7 or later.

$100, www.adobe.com

Your camel, or horse, is an indispensable friend for long desert journeys.

Matching your level to that of enemies is essential.

The viewpoints put Photo Mode to good use.

This Greek has marital problems only you can solve.

Assassin's Creed Origins

A leap into the unknown leads to revelations

WE DON'T KNOW what's what. *Assassin's Creed* is no longer an annual event, and no longer a game in which you hold down your controller's right trigger, and run at things. It might take us some time to get over this.

No more right trigger—that now unleashes a heavy attack capable of killing an unfortunate civilian in a single hit. You now run at things while holding the A button down, and this simple switch is just the tip of a whole iceberg of changes.

Ancient Egypt suits *AC,* what with all those big stone monuments to run at, holding A. It's a wider environment than the cramped streets of Victorian London we slunk through in *Syndicate,* bringing back memories of the dreadful *ACIII's* forests. But in a good way. The weapons are suitably deadly, too, all with extra effects such as bleeding or poison baked into them. This, combined with gaining XP to level up and put Ability Points into a range of skills, makes *Origins* feel more like an RPG than the series ever has before.

Playing as the handsome Bayek, you set about assassinating five leaders of a cult-like group, and end up traveling across Egypt, getting into trouble with invading Romans, before becoming—with your sister, in a neat parallel with *Syndicate*—the first Assassins, and kicking off the whole series. It's their fault, basically.

The inevitable modern-day sections are forgettable. Apart from confirming that *AC* and *Watch Dogs* take place in the same universe, they add little other than acting as a framing device for the main action, providing a rationale for why it's happening, and the usual nonsense about orbs and Pieces of Eden continues to make everyone shrug just as it did in last year's movie.

Microtransactions are again liberally sprinkled through the game, although it is possible to play satisfactorily without troubling your wallet. There's plenty available for free, using your Ubibucks from within UPlay to purchase equipment and costumes, and Helix Points in the game to acquire more in-game currency—drachmas, as we're in the Ptolemaic period when Egypt was run by Greeks—and "time savers," such as packs of extra Ability Points. It's starting to feel like we're being softened up for the day these are no longer optional extras, and are only available in exchange for real money, but for now, it's a free way of getting additional gear, and doesn't affect the game in a negative way.

The extra year in development shows, and *Origins* is the best *AC* title since *Black Flag.* The new structure and minimal HUD mean an end to the clutter that got in the way of enjoying the game, leaving you free to hold down A and run, leap, and glide about an intoxicating world. –IAN EVENDEN

VERDICT **8**

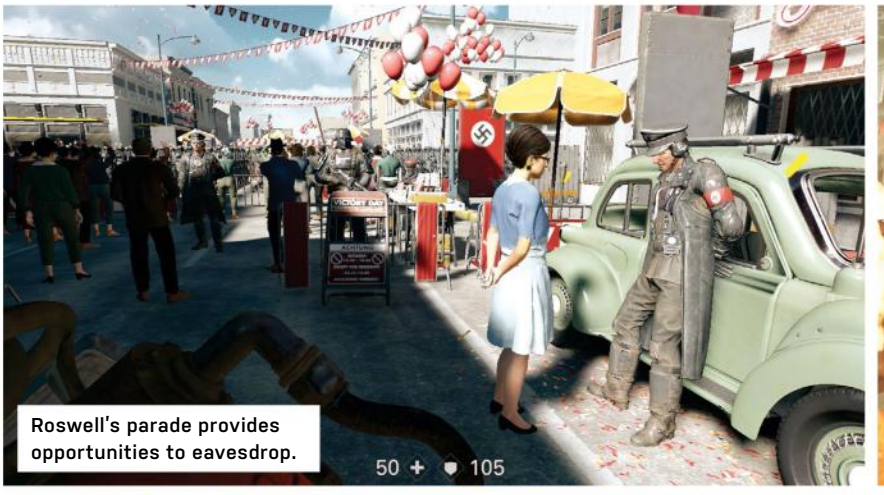
Assassin's Creed Origins

CREED Beautiful; more like an RPG than ever; exhilarating world to run through.

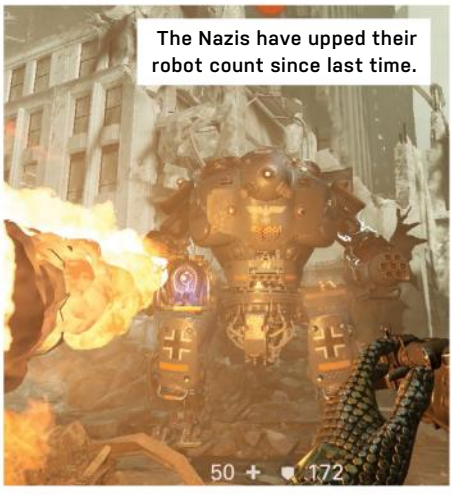
GREED The continued rise of the microtransaction makes us a little uneasy.

RECOMMENDED SPECS Intel Core i7-3770 or AMD FX-8350; 8GB RAM; Nvidia GeForce GTX 760 or AMD R9 280X.

$60, http://assassinscreed.ubisoft.com, ESRB: M



Roswell's parade provides opportunities to eavesdrop.



The Nazis have upped their robot count since last time.

An arcade machine plays a new version of *Wolfenstein 3D.*

The KKK aren't that good at studying German.

Wolfenstein II: The New Colossus

Guns, grit, and Germans in a blazing, if familiar, sequel

MACHINEGAMES' SUBLIME retrofuturistic reimagining of a Nazi-dominated 1960s has been screaming for another visit. *The New Colossus* moves things on five months from *The New Order,* with BJ Blazkowicz recovering from the injuries he suffered while taking out General Deathshead.

Which explains why he's in a wheelchair. This doesn't stop him from taking out Nazis, of course, even on a submarine. The opening sequence—after cutscenes establishing BJ's father as a white supremacist, dog-shooting scumbag—seems trickier than the previous game's. The supersoldiers make an appearance much sooner, and while you're able to salvage a suitably large weapon from their smoking biomechanical corpses, we do miss the armored dogs.

The New Colossus keeps *The New Order's* hub level structure, from where you can initiate missions by talking to the right person, and carrying out activities such as the infuriating fueling of a helicopter by pumping gas from your own flamethrower.

Once you're out in the world, one in which Germany won the Second World War, and the United States has fallen to fascist domination, there are some imaginative sights to see. A ruined New York City is starkly beautiful, picked out in shades of brown and gray, and patrolled by enemies who have the good grace to wear yellow suits. Roswell, New Mexico, is all sunny skies and bright colors, as a parade passes through, and jets stage a flypast overhead.

Roswell is the "disguise" section, like the Nazi moonbase in *The New Order,* and is again marked out by your disguise being almost perfect until you take it off. It's less inexplicable than in the previous game—you do at least eventually get recognized by a dolt of a Nazi officer—but the period before this is one of the game's best, as you admire the wonderfully designed cars, and wonder why every book stall sells the same books in the same order. Must be some Nazi law. Later, something remarkable happens, but all in cutscenes—something the entire game is guilty of.

For the most part, *The New Colossus* is a linear corridor shooter. It mixes things up with some neat lighting changes and the ever-present threat of bonkers sci-fi creations to shoot at, but you're not going to find an open world here. It makes up for this with guns that have heft, weight, and plenty of ammo, enemies who are so evil it would be a crime not to shoot them, and an actual feeling of sympathy for BJ, who believes he's blown it, fears he is about to die, and worries about his pregnant girlfriend.

While this is a suitable sequel to *The New Order,* it lacks some of the freshness of that game. We've seen a lot of this before, but where *The New Colossus* does shine, it puts up a blinding display. **–IAN EVENDEN**

VERDICT 7

Wolfenstein II: The New Colossus

REVOLUTION Great looks and sounds; imaginative enemies; fun blasting.

RETRIBUTION Can feel linear and familiar.

RECOMMENDED SPECS AMD FX-9370, Ryzen 5 1600X, or Intel Core i7-4770; 16GB RAM; Nvidia GTX 1060 or AMD Radeon RX 470.

$60, http://wolfenstein.bethesda.net, ESRB: M

LAB NOTES

BO MOORE, TECHNOLOGY EDITOR

Eggs Over-Clocked

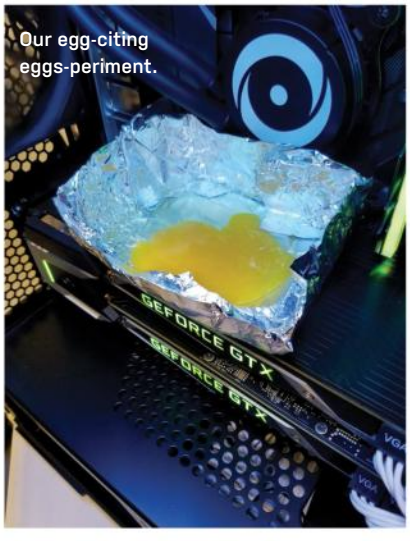
Yes, we really cooked an egg in a PC

IF YOU READ OUR REVIEW of the Origin PC Neuron (pg. 74), you'll notice a bit of an oddity. That's right, we cooked an egg inside a PC. No, this won't be a regular addition to our testing suite, but it was a fun experiment that really demonstrates how toasty it can get inside our gaming machines.

Anyway, let's talk about our egg-cooking methodology. I got the idea when I noticed heat pouring out the blower-style fans on the back of the Neuron. The rig sports dual GTX 1080 Ti GPUs, each of which can get pretty hot in their own right. I measured temperatures around 80 C coming out of the air vents in the back, while the top of the GPUs inside measured as hot as 85 C. This was while running *The Witcher 3* at 4K ultra settings (which looked amazing, by the way).

Using a little boat made of aluminum foil, we cracked an egg and set it on the GPU shelf. The temperatures there were hot, but not quite hot enough to directly cook the egg from the bottom. What really did the trick was putting a second piece of foil on top, creating a nice little mini oven within the larger oven-like enclosure of the system. Even better, the Neuron's Phanteks Evolv case is equipped with easy-open doors on hinges, making the whole process feel a bit like opening an oven to check on a frittata.

Speaking of frittatas, that probably would have been a better egg dish for our PC cooking adventure. The sunny side up option we went with here didn't really play well with our double-oven situation. It did cook, but wasn't exactly the most palatable dish on the menu. The top was cooked to a hard shell, while the inside was a bit of a goopy mess. Edible, but not exactly tasty. Next time, I'll opt for a baked frittata.



Our egg-citing eggs-periment.

ZAK STOREY

Deputy Editor

So, I've finally finished the preparatory work for the big build I've got coming up: another treacherous liquid-cooled system. All the parts have been requested, and the plans have been made (boy, do I need to learn how to use CAD). I finally committed to delidding the Intel Core i9-7900X, replacing the stock thermal paste (which genuinely felt like putty) with liquid metal instead, and then gluing it back down again. The results have been incredible. At a 4.4GHz overclock, with 1.2V in our testing suite, temperatures dropped by an average of 13.5 C. Don't worry, we'll have more on this and a DIY guide in a forthcoming issue (in case you're as insane as I am.)

TUAN NGUYEN

Editor-in-Chief

While the world cheers on 4K, and some manufacturers have even introduced 8K displays, a little detail slipped through HDMI's official 2.1 spec sheet: It'll support 10K at 120Hz. The problem is driving that many pixels. Current GPUs can usually maintain 4K at 60fps in current games, perhaps with a few tweaks to the settings. 5K is 78 percent more pixels than 4K, and 10K is four times as many as 5K. Then double the requirements again to hit 120fps. That would be over 14 times as many pixels as 4K, or 55 times as many as 1080p. If we assume an increase in GPU performance of 30 percent per year, it will take 10 years before GPUs can handle 10K panels at 120fps in games. Your grandkids will love it.

Editors' Picks:
Digital Discoveries

Jarred Walton, senior editor, and Alan Dexter, executive editor, tell us about their top tech tips of today

GOPRO HERO6 BLACK

GoPro's latest Hero6 Black takes everything you love about GoPro and ups the ante. It can do 4K60, 1440p120, and 1080p240, all with the excellent image quality and versatility we've come to expect. This is thanks to the new GP1 processor, which also adds HEVC support, improving image quality with better colors and dynamic range, and less noise.

The Hero6 has waterproofing to 10m, and mount and accessory compatibility that includes everything you'd need. Its compact size allows it to go places other cameras can't, including drones, helmets, and more. For the perfect way to capture your sweet aerial moves, look no further. Improved 5GHz Wi-Fi also enables faster uploads.

There are a few caveats. First, battery life is short, so take a spare battery or three if you're planning on a lengthier session. The digital image stabilization also isn't quite as good as optical image stabilization, so a good grip or clip is highly recommended.

If you don't need the higher resolutions and frame rates, the Hero5 Black is more affordable, but if you want the best action camera this side of 2019, you're unlikely to beat the Hero6. Just make sure you have a PC that can handle the demands of HEVC.

$500, www.gopro.com

FCIV UTILITY

I've been sniffing around cryptocurrency mining again. Mainly out of curiosity, but also to see if it's worth doing. I found myself looking at NiceHash (www.nicehash.com), with its promise of a simple interface and support for all the main mining algorithms. You do get paid in Bitcoins, regardless of what you're mining, but as a simple solution, it's got a lot going for it.

You may have noticed that NiceHash isn't my "pick," though, and that's because after downloading the NiceHash utility, I did something I don't do enough. I decided to make sure that the file I downloaded was indeed the one that the originator intended. I verified the checksum. There are plenty of stories of installers being replaced on reputable sites, and malicious software finding its way into our systems.

Windows 10 ships with a tool for checking a file's checksum, called certutil, and you run it from the command prompt. However, there's another Microsoft tool called FCIV, or the File Certificate Integrity Checker, which is a bit easier to use. Download it from http://bit.ly/2BvfQKQ, then check the MD5 checksum with "fciv -md5 <filename>." Just make sure the checksum you're comparing it to hasn't been compromised as well.

Free, www.microsoft.com

Availability and description of the File Checksum Integrity Verifier utility
Summary
File Checksum Integrity Verifier

GEEK TESTED & APPROVED

Ecoffee Cup

CONTROVERSIAL DEP ED TIME. We don't really talk about climate change here at *Maximum PC*. It's one hell of a polarizing topic. But what is hard to ignore is how much waste we produce as a species. In particular, the trash that ends up in the oceans. Great for survivalists stranded on a desert island; less great for the things living in the sea.

One of the things close to my heart, however, is coffee. I pick up a cup of the good stuff every day on my way to work, drink my beany beverage, and chuck the not-so-biodegradable cup in the trash.

It's a pretty shitty statistic, but an estimated 500 billion coffee cups are thrown away each year worldwide, with more than 99 percent of them non-recyclable. To combat this, I decided to try out a more permanent alternative to my coffee conundrum: an Ecoffee Cup. Designed in the UK, and shipped to the US by the power of Amazon, Ecoffee Cups are predominantly manufactured from recycled bamboo husk. BPA and phthalate-free, they come with a food-safe silicone lid and sleeve, and are even dishwasher safe (although you should dodge the microwave).

All in all, it's a nice cup. There's no plastic aftertaste, and the only downside is the slight smell of silicone emanating from the lid, which I assume will dissipate over time. It's not exactly cheap, coming in at $16.31, but that said, I do now get a discount with my local coffee shop, and the satisfaction of knowing that I've cut down on the amount of excess waste I produce, too. **–ZS**

$16.31, www.ecoffeecup.eco

LETTERS

WE TACKLE TOUGH READER QUESTIONS ON...

> Cover Coolers
> Missing Safe Mode
> Bitcoin Clarification

Spare Gigabytes

In Zak Storey's Build It article in the December 2017 issue, on page 71, in the ingredients, he lists: "Storage 1: 80GB Crucial BX300 2.5-inch SSD $145.00." In the article, on the same page, he states: "a 480GB Crucial BX300." That's quite a difference between 80GB and 480GB, so which did he use?

–Arthur Hazboun

EXECUTIVE EDITOR ALAN DEXTER RESPONDS: Well spotted. That's a typo on the ingredients list—it should be 480GB. Normally, you'd look at the price and realize what it's supposed to be from there, but $145 seems low for a 480GB drive, and too high for 80GB, so we see the confusion. We did review the drive on page 86 of that issue, showing the right capacity, but normally we'd get the ingredients list correct, and you wouldn't have to guess. The usual gremlins have been blamed and given the boot. Apologies for any confusion.

Cover Stars

On the front cover of the December issue, dead-center, under the headline for the lead story, "Today's Best Upgrades," was a picture of a Corsair ML120 Pro case fan. Except for an enlarged photo of the cover shot printed on page 27, I found no mention in that article of the Corsair ML120 Pro case fan, case fans in general, or any mention of the Adata XPG, or Crucial Ballistix Sport DDR4, also in the photo.

So, my question is: Did parts of the article that may have covered these components end up on the cutting-room floor, or was this photo picked because the color red in these components went nicely with the yellow and red theme of the cover?

Also, I'd like it if your writers could mention what the cut-off dollar amount is for the budget, mid-range, and turbo builds for "The Builds" section located at the rear of the magazine. They seem to never mention what that magic number is that they're trying to stay beneath. **–Michael Knight**

EXECUTIVE EDITOR ALAN DEXTER RESPONDS: We originally had the ML120 Pro shortlisted to be included in the feature, because it is certainly the case cooler we recommend, but then realized it didn't fall under the remit of being released in the last year. So, we still definitely recommend it, but it didn't make the feature on a technicality.

As for the prices we aim for on the builds at the back of the issue, they're not actually set in stone, but more nebulous ideas that we feel are right for the current market. Today's prices for RAM and SSDs mean that systems are a little higher than we would like, so we tend to fight harder to find good deals there, but the figures we're aiming for are definitely subjective. Of course, if there's a price you really want us to build to, drop us a line to let us know.

Stay Safe

I have not seen the removal of Safe Mode from the Fall Creators Update mentioned anywhere. Am I the only one who has noticed?

I recently plugged in a second Bluetooth receiver by mistake, and then things went downhill. The PC got stuck in an endless boot loop, from which I could not recover. In trying to boot into Safe Mode to attempt the removal of any bad or corrupt drivers, I could find no way to do so—not from a recovery media or the install media.

What is one supposed to do if they need Safe Mode? I ended up doing a complete reinstall, losing all my activated software.

–Lee Boszak

EXECUTIVE EDITOR ALAN DEXTER RESPONDS: Safe Mode is still present, though it has shifted around quite a bit in recent releases of Windows, so I'm not at all surprised that you think it's disappeared. To find it, type "Safe" into the Start menu to open the Recovery options page in the Windows Settings panel. Here you'll find two sections: "Reset this PC" and "Advanced Startup." Click the button titled "Restart now" under "Advanced Startup," and then, after a reboot, press 4 to start Safe Mode. If you're having problems getting into Windows in the first place, rebooting your machine three times by holding down the power button

↘ submit your questions to: comments@maximumpc.com

forcing Windows to get to the same screen.

Bits of Coin

I read with interest your article "The Rise of New Money" in the November 2017 issue. I'm still having a hard time getting my head around how cryptocurrency works. I have two questions I've never seen addressed: If I don't mine cryptocurrency, how do I obtain the currency? And let's say I have obtained one Bitcoin, and its value currently is $5,000. Now I go to a retailer who accepts Bitcoin, and I buy a $1,000 TV. In what form do I get my $4,000 change? Are there fractional Bitcoins? **–Jack Mangold**

EXECUTIVE EDITOR ALAN DEXTER RESPONDS: The time to mine Bitcoins has definitely passed, but you can still buy and sell them using a Bitcoin exchange (such as Kraken, Coinbase, and so on). Once you do buy Bitcoins (or a fraction of a Bitcoin), they're held on the exchange in a wallet, and any leftover coins (or fractions of) are left in the wallet. At the time of going to press, Bitcoin is enjoying another one of its volatile moments, which has seen its price hit over $10,000. So, buying a TV would leave plenty of coin left in your wallet for future purchases or investment. We'll be visiting cryptocurrencies again soon, with practical advice for dealing with them on a day-to-day basis.

Viewing Events

Great article on speeding up the PC in the December issue. It made me think that, aside from always trying to get more speed, one of the things that has always driven me crazy about Windows is all the "administrative events" reported by Event Viewer. Ever since Windows and I have known each other, it says that my DistributedCOM is not happy, and my DNS Client Events are trying to warn me about something. I have always been told that all this can be fixed, and that all I had to do was ask Mr Google. Well, when I tell Mr Google that "The application-specific permission settings do not grant Local Activation permission for the COM Server application with CLSID," he coughs a bit, then launches me into complex, multi-option proposals for fixing this problem, which seem to be mainly suggestions from well-meaning folk.

So, my question to you is: Would you write an article on the best way to get rid of all these errors and warnings? Tell us what the most common ones are, and how to fix them. Tell us about the most serious. Let us know if it's worth investing all the time I have to fix these. Hell, why not start a contest to see if anyone can show us a clear Events log. I'd even contribute to a prize.

–Len Babin

EXECUTIVE EDITOR ALAN DEXTER RESPONDS: That sounds like a reasonable idea. While you should always be able to find responses for the more esoteric problems, common issues should be easily found. Leave it with us.

Secure Knowledge

I believe that there's a significant error in the "Secure Your Network Devices" article, which appeared in the December 2017 edition. When discussing subnets and VLANS, the author claims that "You can identify which subnet a device belongs to by the first three numbers in your IP address...." That's only true when the device is configured to use a 24-bit subnet mask (255.255.255.0). Granted, that's probably the most common configuration out there, particularly in small and home offices, but it simply isn't possible to determine a subnet by looking at the IP address alone. **–Phil Hoffman**

EXECUTIVE EDITOR ALAN DEXTER RESPONDS: You're absolutely right in terms of the bigger picture, but at the same time, this was written in fairly basic terms for anyone trying to secure their home network. And from an internal perspective, this is enough to just know that you've set up a device on the right subnet (assuming, of course, that you've set up the subnets yourself).

Sound & Vision

I just installed GeForce driver 388.31, and my motherboard sound stopped working. I did all the usual things—changing default sound device, uninstalling sound drivers, rebooting, and so on. I found a workaround by using the audio jack on my Asus display, driven by my GPU, but hardly optimal.

–Rona Matllow

EXECUTIVE EDITOR ALAN DEXTER RESPONDS: It sounds as though your audio drivers have defaulted to the HDMI output supported by your graphics, as opposed to the one that was on your motherboard. The standard response here is to go to the Sound settings in the control panel, and make sure you have headphones/speakers selected as the default playback device, and not the Nvidia Output option. However, as you've said you've already checked this, it is probably down to a driver conflict. The solution here is to uninstall your current audio drivers, then reinstall them again (you'll find the drivers on Asus's website).

[NOW ONLINE]

WHAT THE THREAT AGAINST NET NEUTRALITY MEANS FOR PC GAMING

On November 21, 2017, FCC chairman Ajit Pai announced his intent to "repeal the heavy-handed Internet regulations imposed by the Obama Administration and to return to the light-touch framework under which the Internet developed and thrived before 2015." These plans to limit the FCC's power and remove regulations protecting Internet users in the US will give companies like Comcast more power to shape how we use the Internet, despite Pai's claim that "the FCC would simply require Internet service providers to be transparent about their practices, so that consumers can buy the service plan that's best for them, and entrepreneurs and other small businesses can have the technical information they need to innovate."

Read the full article at http://bit.ly/1DrPHJK

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THE BUILDS

BUDGET

INGREDIENTS

PART		PRICE
Case	Phanteks Enthoo Evolv ITX	$70
PSU	EVGA 450B Bronze	$45
Mobo	ASRock AB350 Gaming-ITX/ac	$95
CPU	AMD Ryzen 3 1200	$110
GPU	EVGA GeForce GTX 1050 Ti SC Gaming 4GB NEW	$158
RAM	8GB (2x 4GB) Patriot Viper Elite DDR4 2666	$105
SSD	Team Group L5 LITE 3D 2.5-inch 120GB NEW	$55
HDD	1TB WD Blue 7,200rpm	$50
OS	Ubuntu Desktop Linux 16.04 LTS 64-bit	$16

Approximate Price: $704

THE MEMORYPOCALYPSE has reared its ugly head again. Our Ryzen-compatible DDR4, which gave us a saving last issue of $3, has leapt in price by a worrying $30. The world needs more RAM, dammit, and soon. We're not just going to sit here and take this gouging—we're going to complain about it. But, equally, we can't let memory tell us what to do, so we're sticking with our recent switch to an easily upgraded Ryzen 3 setup, the chip of which you may be able to pick up for 10 or so bucks less if you check on the right day. To make up a little of the cash absorbed by that RAM, we tossed out our old MSI 1050 Ti GPU, and dropped in an equivalent superclocked EVGA version that's $5 cheaper. Then we cursed at the out-of-stock L5 LITE SSD, which forced us to switch to its 3D version, and that cost an extra $7 on top. So, our budget system is less budget than before, but that's still a hell of a machine for the price.

MID-RANGE

INGREDIENTS

PART		PRICE
Case	NZXT S340 Elite	$99
PSU	EVGA SuperNOVA 550 G2	$90
Mobo	MSI X370 SLI PLUS	$140
CPU	AMD Ryzen 5 1600	$233
Cooler	Enermax ELC-LMR240-BS Liqmax II NEW	$90
GPU	Asus GeForce GTX 1070 Ti TURBO 8GB NEW	$450
RAM	16GB (2x 8GB) G.Skill Ripjaws V Series DDR4 3200	$215
SSD	Samsung 850 EVO M.2 2280 250GB NEW	$106
HDD	Western Digital Blue Series 1TB 7,200rpm	$50
OS	Windows 10 Home 64-bit OEM	$100

Approximate Price: $1,573

BUY CLEVER, and this build could cost you a whole lot less. There are at least $65 worth of mail-in rebates lurking in there, and we canvassed prices (worst luck) just following the end of a big sale period. Times were not the kindest to us—they may be kinder to you. With our mid-range monster suffering price hikes across the board, we've bitten the bullet and made a few switches. Zotac's GeForce GTX 1070 Mini, once a bargain, leapt up to $420, making spending an extra $30 and jumping to Asus's nice-priced 1070 Ti far less worrying. To offset that and other rises (cough, RAM, cough), we've switched out the cooler for the lowest-end AM4-compatible radiator we could find ($40 saving), and specced down the SSD just a little to save another $60. Not that these changes will impact the grand vision of this machine: Ryzen 5 and that 1070 Ti in tandem will tear through 1080 and 1440p games, and you can push the clocks if you wish.

BACK DOWN MEMORY LANE AGAIN. Last issue, we complained about having to pull our high spec rig down to using a lower spec RAM kit: four 8GB sticks of RGB-flavored G.Skill TridentZ that cost a whopping $10 more than the RAM from our previous build. This issue, that same kit has jumped up another $10. No, wait, missed a zero: $100. Our solution, given there's no other option, is to take the hit. Our PSU has gone up in price, but staying modular and keeping the wattage up is all but essential, so we've stuck with that, too. One saving grace: At press time, the fantastic 12-core 1920X was on offer, absorbing pretty much every cent of the additional outlay elsewhere, and if you see a Threadripper for under $700, you are under orders to snap it up.

On top of that chip, we've finally switched out the NZXT Kraken radiator for a more traditional air cooling solution. It's a chunk cheaper, but Noctua's NH-U14S, finally available on Newegg, really works—with the airflow of an additional 140mm NF-A15 fan, it drags through enough air to quell the heat of even a fully clocked 4GHz 16-core processor in the throes of epic rendering.

This machine can do just about anything. Its GTX 1080 Ti is nigh on unstoppable, the Ryzen CPU is, though, being stared down by Intel's eighth generation crop—a real, ahem, bulldozer—and sticking with a reasonably high-end RAM setup means we're not going to be fighting with any bottlenecks any time soon. Expect the lineup to change significantly over the next few months, though, especially that case.

For more of our component recommendations, visit www.maximumpc.com/best-of-the-best

INGREDIENTS

PART		PRICE
Case	Phanteks Eclipse P400S Tempered Glass Silent Edition	$90
PSU	Corsair RM750X Modular Gold	$130
Mobo	Asus Prime X399-A	$350
CPU	AMD Ryzen Threadripper 1920X	$650
Cooler	Noctua NH-U14S TR4-SP3 140mm + NF-A15 PWM NEW	$102
GPU	MSI GeForce GTX 1080 Ti ARMOR 11G OC	$720
RAM	32GB (4x 8GB) G.Skill TridentZ RGB DDR4 3000	$460
SSD	512GB Samsung 960 Pro M.2 NVMe	$330
HDD	4TB WD Black 7,200rpm	$185
OS	Windows 10 Home 64-bit OEM	$100

Approximate Price: $3,117

UPGRADE OF THE MONTH

NOCTUA NH-U14S

Moving backward from liquid cooled AIOs is an odd thing to do—we'd only just gotten comfortable—but the results of Noctua's stand-up cooler, developed in the chilly mountains of Austria, really do speak for themselves. Given adequate airflow inside your case, you'll see stability, you'll see results, and the fans are large enough that you likely won't hear about it even under heavy load, provided you have room for the massive 140mm heatsink. Don't let the taupe and brown hardware put you off—this is PWM-controlled air movement that can't be beat. Brown means good, see? Doubling up with a second, equally brown fan on the other side is highly recommended, too—it's a quick fit, and a cheap extra. **$80, www.noctua.at**

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